Integrated quarry rehabilitation strategy for sustainable renaturation in Lebanon

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von
M.Sc. Adel Joseph Yacoub

dem
Präsident der Humboldt-Universität zu Berlin
Prof. Dr. Dr. h.c. Christoph Markschies

Dekan der Landwirtschaftlich-Gärtnerischen Fakultät
Prof. Dr. Dr. h.c. Otto Kaufmann

Gutachter:

Doz. Dr. sc. Dres. h. c. Michael Böhme

PD Dr. sc. Frank Riesbeck

Assoc. Prof. Dr. Youssef Sassine

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ABSTRACT

Throughout Lebanon's history, quarries have been used as a means to extract essential construction materials such as sand, aggregates, stone masonry, cement, block stone, and others. Due to complexity of the quarry sector in Lebanon very few data are available, records and studies in this field are limited. Therefore, the presented research tackles one of Lebanon's most pressing issues and represents the most updated database on quarries in Lebanon. A comprehensive and integrated overview of the quarries issue in Lebanon in general and the problem of rehabilitation in particular is given and the problematical topic of an integrated quarry planning within a sustainable development concept in Lebanon is pointed out. Milestones and landmarks toward the adoption of a setup needed for the proper rehabilitation approach at different levels as public sector, private sector and local communities are developed.

The aim of the research was to study the issue of integrated quarry planning for sustainable development in Lebanon and to enhance the understanding of sustainable quarrying management practices in Lebanon.

First part of the research aimed at collecting information about the types of quarries existing in Lebanon, their status of rehabilitation and the current rehabilitation practices. The information and data were collected using two methods: firstly an in-depth desk survey complimented by data from the remote sensing (GIS) and secondly an own randomized field survey. In the second part of this research, management strategies for rehabilitation of quarries and an algorithm for quarry rehabilitation should be developed.

In total 471 investigation sites according to an inclusive data sheet were considered out of the entirely 776 estimated quarries based on the results of the desk survey activity. This quantitative survey enabled us to quantify different parameter among them also the rehabilitation status of quarries in Lebanon. The results clearly indicated that only 0.8% of the quarries were rehabilitated, 13% were partially rehabilitated and the rest of 86.2% of the remaining quarries were neither rehabilitated nor re-naturated causing environmental damage and financial losses. National and international literature was reviewed in order to identify gaps and consequently recognize barriers that are hindering the rehabilitation.

Finally a recommendation for a multidisciplinary approach for sustainable quarry rehabilitation is given that could be adopted by the government of Lebanon after getting the approval of all concerned stakeholders. In fact this algorithm in its four dimensions as legal, technical, institutional, and financial dimension needs two years to become realised. The promulgation of two decrees (No 8803 in year 2002 and its amendment the decree No 16456

in 2006) by the Ministry of Environment was indeed an asset but nonetheless it was not quite enough to ensure the proper rehabilitation of the quarries in Lebanon due to several reasons.

The proposed algorithm will be pioneer for three major reasons: i) approving a mining region in Lebanon or the quarry master plan, ii) stop/forbid the issuance of the called administrative extensions and iii) propose a real setup for the abandoned non-operational quarries to be rehabilitated properly by law.

To validate the theory (resulted in the research recommendations) and evaluate it in practice, a field experiment was established between 2007 and early 2008 to practically implement a rehabilitation scenario on a part of an old quarry located in Sibline village situated in the northern side of Beirut the capital of Lebanon. Using the DPSIR Framework Model (driving forces, pressures, state, impacts, responses) adopted by the European Environmental Agency in 1999, in addition to several relating materials it was possible to conceptualize the quarry rehabilitation process in the Lebanese context.

The rehabilitation operation was initiated by the Government of Lebanon and extended over 7 months during year 2007 and early year 2008. This operation included backfilling of around 15.000 m^2 of the quarry base level with around 85.000 m^3 of inert material transferred from the Normandy Landfill. The rehabilitation was finalised by restoring the site by adding a layer of top soil and the cultivation of carob trees (*Ceratonia siliqua*). By this case study it was possible to address a sustainable procedure for natural resources management, examine and validate the different results and the outcomes of the thesis and compares them to the different variable, variance, parameters, criteria that regulate most the quarry rehabilitation process in Lebanon.

Finally, the thesis works succeeded in laying the way towards an integrated approach to the natural resources management in Lebanon. However further steps are still needed to multiply the case study in different areas with different type of exploitation. It is important to note that the financial aspects were not subject of discussion in this case study but it will certainly be a key issue in other case studies in this context.

This research will certainly lay the way for other complementary studies and research from different scientific perspective (socio-economy, ecology, biology, agriculture, landscape engineering, geology, hydrogeology etc…) to be executed in this field.

Finally, this study resumed answers to the five most frequent asked questions i) why there is no to little rehabilitation in Lebanon, ii) when to rehabilitate, iii) which quarries to rehabilitate first, iv) how to rehabilitate and v) who is responsible for rehabilitation.

ZUSAMMENFASSUNG

In der Geschichte Libanons sind Steinbrüche immer für die Gewinnung von Baumaterialien wie Sand, Kies, Steine, Zement usw. genutzt worden. Durch die Komplexität dieses Sektors im Libanon gibt es kaum verfügbare Daten, Erhebungen und Studien über Ausmaß und Auswirkungen der Abbautätigkeit. Deshalb behandelt die vorliegende Untersuchung eines der drängendsten Probleme und legt eine aktuelle Datenübersicht über die Steinbrüche vor. Es ist ein vollständiger und integrierter Überblick über die Steinbrüche im Libanon im Allgemeinen und das Problem ihre Rehabilitation im Besonderen unter Berücksichtigung des schwierigen Themas eines integrierten Steinbruchmanagements in einem nachhaltigen Konzept. Meilensteine und Etappen bei der Etablierung eines Rehabilitationsprogrammes werden auf unterschiedlichen Ebenen wie der öffentliche Sektor, der private Sektor und den öffentlichen Kommunen entwickelt.

Ziel der Arbeit war die Entwicklung eines integrierten Programms zur Steinbruchplanung für eine nachhaltige Entwicklung im Libanon und die Förderung des Verständnisses für ein nachhaltiges Steinbruchmanagement.

Der erste Teil der Arbeit zielt auf die Sammlung von Informationen über die im Libanon existierenden Steinbruchtypen, ihren Status der Rehabilitation und die gegenwärtige Rehabilitationspraxis. Die Informationen und Daten wurden mit zwei Methoden gesammelt: erstens durch Auswertung sekundärer Datenquellen mittels GIS und zweitens durch eigene Erhebungen. Im zweiten Teil der Arbeit wurden Managementstrategien für die Rehabilitation und ein Algorithmus dafür entwickelt.

Insgesamt wurden 471 Orte untersucht, die nach Auswertung der sekundären Daten aus insgesamt wahrscheinlich 776 Steinbrüchen ausgewählt wurden. Diese quantitative Betrachtung ermöglicht verschiedene Parameter zu quantifizieren darunter auch den Rehabilitationsstatus der libanesischen Steinbrüche. Die Ergebnisse belegen ganz klar, dass nur 0,8% der Steinbrüche rehabilitiert sind, 13% teilweise rehabilitiert sind und der Rest von 86,2% der Steinbrüche weder rehabilitiert noch renaturiert sind was Umweltschäden und finanzielle Verluste verursacht. Nationale und internationale Literatur wurde ausgewertet, um Lücken und Hindernisse für die Rehabilitation zu identifizieren.

Schließlich werden Empfehlungen für einen multidisziplinären Ansatz für eine nachhaltige Steinbruchsanierung gegeben, die durch die Regierung Libanons umgesetzt werden könnten, nach Akzeptanz durch die verschiedenen Entscheidungsträger. In der Tat wird dieser Algorithmus in seinen vier Dimensionen, gesetzlich, technisch, institutionell und finanziell zwei Jahre zur Realisierung benötigen. Die vorliegenden 2 Erlasse (Nr. 8803/2002 und Nr. 16456/2006) des Umweltministeriums sind ein Anfang aber nicht ausreichend die die Rehabilitation der Steinbrüche aus mehreren Gründen.

Der vorgeschlagene Algorithmus wird aus drei Gründen wegweisend sein: i) Entwicklung eines Masterplans für die Bergbaugregionen im Libanon oder eines Steinbruchmasterplans, ii) Regulierung bezüglich der Abläufe im Steinbruchmanagement durch administrative Festlegungen und iii) Vorschlag eines realistischen gesetzlichen Scenarios zur Wiederherstellung und Renaturierung von Steinbrüchen.

Um die Theorie in der Praxis zu überprüfen und zu bestätigen, wurde ein Feldexperiment in den Jahren 2007 und 2008 in einem Teil eines alten Steinbruchs angelegt in Sibline, einem Dorf nördlich von Beirut. Im Rahmen diese Experimentes wurde das DPSIR Rahmenmodel (D-Treibende Kräfte, P-Zwänge, S-Festlegungen, I-Einflüsse, R-Reaktionen) welches 1999 von der Umwelt Agentur der EU als Standard aufgenommen wurde, erfolgreich angewendet. Im Zusammenhang mit weiteren ähnlichen Materialien war es möglich ein Konzept für die Wiederherstellung von Steinbrüchen in Libanon zu erarbeiten.

Die Rehabilitationsmaßnahme wurde durch die libanesische Regierung initiiert und über 7 Monate 2007 und 2008 durchgeführt. Sie beinhaltet des verfüllen von ca. 15.000 m^2 der Fläche des Steinbruchs mit ca. 85.000 m^3 inerten Materials, das von der Normandy Landfill herantransportiert wurde. Die Rehabilitation wurde abgeschlossen durch das Aufbringen einen Bodenschicht und das Aufpflanzen von Carobbäumen (*Ceratonia siliqua*). Durch diese Fallstudie konnte die Nachhaltigkeit der Maßnahme für das Management natürlicher Ressourcen geprüft werden, unterschiedliche Ergebnisse validiert und untersucht werden.

Schließlich kann durch diese Arbeit ein Weg aufgezeigt werden zu einem integrierten Ansatz für das nachhaltige Ressourcenmanagement im Libanon. Trotzdem sind weiter Schritte erforderlich, um die Ergebnisse auf weitere Orte zu übertragen. Außerdem muss darauf hingewiesen werden, dass die finanziellen Aspekte im Rahmen der Arbeit nicht diskutiert wurden, die aber sicher ein Schlüsselfaktor bei der Umsetzung der Vorschläge sein werden

Entsprechende ergänzende Untersuchungen zu sozio-ökonomischen, ökologischen, landwirtschaftlichen, landschaftlichen, technischen, geologischen und hydrologischen Aspekten sind erforderlich.

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LIST OF ABBREVIATIONS

ACS	Administration Centrale des Statistiques
AEI's	Areas of Ecological Importance
ANZMEC/MCA	Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia, Canberra
APA	Aggregate Producers Association
ARA	Aggregate Resource Act
BAA	British Aggregates Association
BACMI	British Aggregate Construction Materials Industry
BANAANAAA	Ban Any New Activity Anywhere Near Anyone At All
BTP	Building and Transport Potential
BTU	Building and Transport Use
CDR	Council for Development and Reconstruction
CFR	Code of Federal Regulation
COED	Cost of Environmental Degradation
DEFRA	Department for the Environment, Food and Rural Affairs
D.R.I.R.E	Regional Departments of Industry, Research, and Environment
EEA	European Environmental Agency
EIA	Environment Impact Assessment
EIS	Environmental Impact Statement
EPS	Environmental Planning Statement
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIS	Geographic Information System
GoL	Government of Lebanon
GPG	Good Practice Guidance
ICIS	International Centre for Integrative Studies
IIED	International Institute for Environment and Development
IPPC	Integrated Pollution Prevention and Control
LAPPC	Local Authority for a Local Air Pollution Prevention and Control
LBP	Lebanese Pounds
LDD's	Local Development Documents
LPP	Local Plan Policy
OECD	Organization for Economic Cooperation and Development
ODPM	Office of the Deputy Prime Minister
OMA	Ontario Mining Association
OMP	Old Mineral Permission
ONDM	Ontario Ministry of Northern Development and Mines
QPA	Quarry Product Association

MAAP	Management of Abandoned Aggregate Properties Program
MAP	Mineral Planning Authority
MEPA	Malta Environment & Planning Authority
METAP	Mediterranean Environmental Technical Assistance Program
MIRO	Mineral Industry Research Organization
MMSD	Mining, Minerals and Sustainable Development
MOE	Ministry of Environment
MOA	Ministry of Agriculture
MOIM	Ministry of Interior and Municipalities
MOSA	Ministry of Social Affairs
MPA's	Mineral Planning Authorities
MPG 7	Mineral Planning Guidance 7
MPS	Minerals Policy Statements
MRA	Maltese Resources Authority
MSW	Municipal Solid Waste
NCQ	National Council for Quarries
NIMBY	Not In My Back Yard
NGO	Non Governmental Organization
NPMPLT	National Physical Master Plan for the Lebanese territory
RPB's	Regional Planning Bodies
RSS's	Regional Spatial Strategies
SEDDPS	Scottish Executive Development Department Planning Services
SAGA	Sand and Gravel Association
SCC	Surrey County Council
SSI's	Sites of Scientific Importance
TGAP	General Tax for Polluting Activities (GTPA)
TOARC	The Ontario Aggregate Resource Corporation
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
WB	World Bank
WBCSD	World Business Council for Sustainable Development
WTP	Willingness-To-Pay

1. INTRODUCTION

1.1 Problem statement

Throughout Lebanon's history, quarries have been used as a means to extract essential construction materials such as sand, aggregates, stone masonry, cement, block stone, and others. However, due to the recently increasing demand for building material, along with substantial financial, technical and legislative barriers, quarries are now on the top the nation's list for environmental priorities.

The entire country is scattered with over 700 quarries established with little consideration to the surrounding environment and settlements and causing:

- Environmental risks (slope stability/ land slide/ hazardous rockfall)
- Permanent loss of biodiversity and natural resources
- Noise and visual pollution
- Air pollution from dust emission
- Pollution of groundwater and surface water resources
- Loss of property value

In fact, conservative studies had estimated that quarries reduce land and property values in Lebanon annually by approximately 0.1% of our national GDP (World Bank, 2004). If these quarries are not rehabilitated, their environmental and socio-economic impacts will remain forever.

As a result of the consecutive wars from 1995 till July war 2006, Lebanon was forced to rebuild several times its infrastructure as the backbone of the country's economy. As a consequence, concerns abound that an incremental demand was met with an uncontrolled increase in local mining and quarrying activities leading to irreversible impacts on Lebanon's fragile environment,

Dar Al-Handasah (1996) pointed out that almost no rehabilitation or only partial rehabilitation do exist in Lebanon, about 71% of quarries in Lebanon did not respect the minimal basic standards and performance criteria. An estimated 70% of the quarries were structurally unstable and 60% were downright dangerous.

The sporadic and inappropriate mining and quarrying practices coupled with a lack of environmental protection laws have led to serious environmental and socio-economic problems. For regulating the quarry sector since 1932 numerous attempts were made to reorganize the quarry sector – although these attempts were deterred by the civil war and political interference. Nonetheless, there have been many governmental efforts aimed at

organizing quarries exploitation and rehabilitation which have recently culminated in the promulgation of new decrees (Decree No. 8803/2002, Decree No. 16456/2006).

Since its establishment in year 1993, the Ministry of Environment worked hardly to build up a reliable set up for quarry exploitation through developing a series of government decrees to organize the sector. The quarry master plan approved by the decree No. 8803/2002 and all its amendments included only 4 regions in Bekaa governorate with limited surface area in which it is allowed to invest all types of quarries in Lebanon. In light of the absence of a satisfying mining region and the high demand for earth material, Lebanon is still facing a major problem in respect to quarry investment and particularly in a missing post closure plan for each quarry.

Most of the quarries existing in Lebanon dates back to before the approval of the decree No. 8803/2002 and are left without rehabilitation. Different barriers still impede the implementation of a sustainable rehabilitation program, including:

- Lack of technical expertise, means and tools to evaluate and monitor quarry rehabilitation at both the private and public levels
- Implicit institutional laws and policies that do not reinforce quarry management
- Complex land tenure issues
- Major financial constraints due to the local socio-economically conditions
- Overlapping of authorities; issuance of administrative extensions
- Outlaw activities and investments
- Missing of a pilot project in order to show an example for renaturation of a typical quarry

1.2 Structure and organization of the thesis

The study includes, in addition to the introduction seven other sections indicating the problems and proposing consequent solutions for an integrated quarry planning in Lebanon.

In fact, the study's eight sections elucidate the following topics:

1. Chapter 1: introduces the problem statement of the thesis
2. Chapter 2: exposes the aim and the objectives and hypothesis of the study
3. Chapter 3: described the general context of Lebanon
4. Chapter 4: elaborates the materials and methods used to complete the study
5. Chapter 5: analyses and discusses the findings and the results of the research
6. Chapter 6: presents an applied pilot case study on how to do a quarry rehabilitation
7. Chapter 7: summarizes the general conclusions, recommendations and perspectives
8. Chapter 8: displays the executive summary of the thesis

2. AIM OF THE RESEARCH

2.1 General aim

The quarries in Lebanon and their rehabilitation status shell be analysed and classified. Based on these results, the quarry management in Lebanon regarding sustainability of renaturation should be characterized. In frame of this research an algorithm for sustainable restoring and renaturation will be developed. Furthermore, a quarry renaturation pilot project will be created.

2.2 Hypotheses

The research is carried out based on the following hypotheses:

1) The current quarry management practice is one of the major factors for land degradation in Lebanon.
2) It is possibly to characterize the quarries in Lebanon and to develop a programme for their renaturation.
3) Sustainable quarry management needs an administrative network in order to reduce the negative impacts of the current quarry management.
4) The administrative procedures and the financing measures have to be improved in order to secure the rehabilitation programmes of quarries.
5) An algorithm can be developed for sustainable renaturation and restoration of quarries.
6) A pilot quarry rehabilitation project can demonstrate the realisation of the algorithm for rehabilitation and renaturation.

2.3 Research objectives

The objectives of the research are as follows:

1. Investigation of the situation from abandoned and active quarries in Lebanon regarding their functionality, status of use and rehabilitation activities in different regions in Lebanon
2. Analysing of the historical and current practices in quarry management in Lebanon by using of literature and documents of the administration
3. Verification of the status of rehabilitation practices in various types of existing quarries in Lebanon
4. Identify the barriers that hinder the development and implementation of a sustainable rehabilitation program
5. Analysing of the internal and external environmental and socio-economic impacts caused by the quarries and recommendation for the mitigation of those impacts

6. Analysing the international literature and available documents regarding administrative management and rehabilitation programmes
7. Development an algorithm for quarry rehabilitation in Lebanon for new and non-rehabilitated quarries
8. Preparation and realisation of pilot project as case study for a sustainable renaturation of a closed quarry to demonstrate the suitability of the algorithm and to show the procedure for natural resources management
9. Recommendation for further sustainable quarry management in Lebanon

2.4 Benefit of the studies

The administrations in different levels, quarry companies and other stakeholders have an overview about the strengths, weaknesses, opportunities and threats of the current quarry management. The data collected about quarry management in selected countries as well in Lebanon can be useful for all those involved in quarry management or burdened of the negative quarry impacts. The understanding of the possibilities for sustainable quarrying management practices can be enhanced through the development of a model for quarry rehabilitation, based on the result of this research. The rehabilitation scenario of the pilot project can be multiplied for other abandoned quarries. The research can be useful for better environment protection and protection of the biodiversity in Lebanon.

3. BACKGROUND AND LITERATURE REVIEW

3.1 Geographic characterization of Lebanon

3.1.1 Topography and soil

The narrow coastal plain and two mountain ranges (Mount Lebanon and the Anti-Lebanon) which run parallel to the coast dominate the physical environment of Lebanon. The two mountains are separated by the elongated Bekaa valley.

The first unavoidable feature or reality of Lebanon is its small surface area. With around 10.452 km^2, it is the second smallest country in the Middle East and the Arab World after Bahrain. Lebanon is positioned in the Middle East, a geographical region of South-Western Asia, bordered by the Mediterranean Sea and the countries of Syria and Israel. It is geographically located in the East coast of the Mediterranean Sea between North latitude 33° 03′ 38′′ and 34° 41′ 35′′ and East longitude 35 ° 06′ 22′′ (ACS, 2006).

The main natural resources of Lebanon are water, sites (mountains, valleys, coastline, etc.), agricultural lands, and natural vegetation (forests, etc.). Being limited, their rational use is more than vital. These resources play an important role in the quality of life, agricultural productivity and tourist attractions. It is necessary to avoid their dilapidation and, on the contrary, use each of them in the most profitable manner.

Out of Lebanon's total surface 52% are rocky, non-cultivated lands and degraded rangelands. The arable lands, mostly located in the coastal plains and the Bekaa valley, are about 260,000 ha representing just 25% of the total land area. Forest cover is very limited. The FAO mapping of Lebanese forests in 1966 showed that only 66,000 ha forests are characterized by a density above 10% and only 10,000 ha are high forests (Baltaxe, 1966).

Lebanon’s geological units are divided according to the geological time scale for two eras with four major periods of different epochs and local subdivisions.

The Quaternary Period (≈ 1.8 MA) is considered the latest geological time in the stratigraphic column, represented by local accumulation of glacial and post-glacial deposits. It is a mixture of sand, clay, silt and gravel in varying proportions and forms. The variation of deposition environments, physical nature and chemical composition divided these materials into different categories such as: Eolian, Alluvium, Fluvial, Colluvial, etc. Soil cover is the most recent deposit of the Quaternary Period specified as the natural medium for growth of land plants and is located at the top few meters of the ground surface. It may also contain organic matters. The different forms of soil covers in Lebanon are described as follows: coastal sand, consolidated dunes, dolomitic sand, conglomerates cemented by calcareous material, and Terra Rosa soils.

Topography is an unavoidable, distinguished and at the same time restricting feature of Lebanon. The mountains of Lebanon have shaped its climate, water resources, landscapes and its extremely rich biodiversity. They had always played a decisive role in the history of its settlements and are still to date.

Topography splits the territory into geomorphological regions, separated by valleys and mountains. It enhances, thus, diversity of the environment, but does constitute physical obstacles to the regions at the same time.

There are five geomorphological regions in Lebanon (Figure 1):

1. The **Coastal zone**, including the shoreline and continental shelf, the coastal plains and the foothills of Mount Lebanon up to elevations of 250 meters. The Lebanese coast is about 250 km long (CDR-ECODIT/IAURIF Study, 1997);
2. The **Mount Lebanon range**, about 160 km long and 25-40 km wide, includes middle and high elevation zones above 250 meters. It rises from Akkar in the North and extends South to the hills of Jabal Amel. Mount Lebanon peaks at 3,088 meters at Kornet es-Saouda in the North.
3. The **Bekaa plain**, a land depression separating the Mount Lebanon and Anti- Lebanon ranges. It comprises an 8-12 km wide fertile corridor and is about 120 km from North to South. The Beqaa plain is drained by the Aassi river from the North and by the Litani River from the South.
4. The **Anti-Lebanon range** extends across the Lebanese-Syrian borders. It peaks at 2,600 meters (Tallat Moussa). Slopes are generally compared to Mount Lebanon. The Southern sections of the Anti-Lebanon range include Jabal el Cheikh (Mount Hermon) which intercepts rainwater and redistributes water into at least three main watersheds across Lebanon, Syria and Israel.
5. The **South Lebanon**, an elevated plateau that extends a short distance inland from the Western shores of South Lebanon to the Mount Hermon foothills in the East. This region is intersected by many seasonal streams flowing from west to east and discharging into the Mediterranean Sea.

Roughly three quarters of the total surface area of Lebanon is mountainous, i.e., Mount Lebanon, Anti-Lebanon, and South Lebanon (Figure 1).This diverse topography gives rise to many microclimates, favourable to the occurrence of many plant and animal species and communities. At the same time, steep terrains are prone to soil erosion and ultimately land degradation if poorly managed. The coastal zone is particularly vulnerable to urban encroachment and loss of habitat (MoA/UNEP, 1996a).

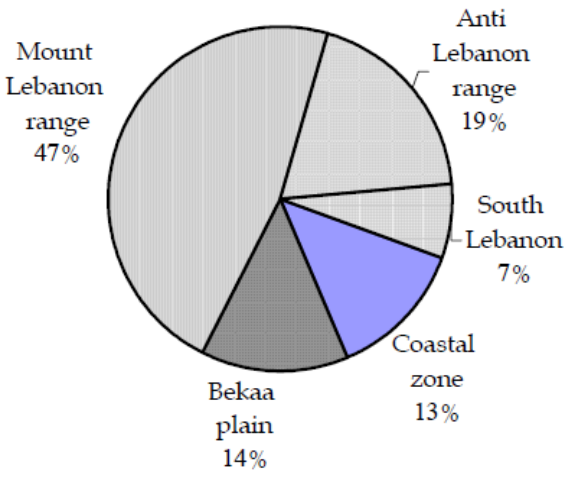


Figure 1 Distribution of geomorphological regions of Lebanon (MoA/UNEP, 1996a)

Lebanese soil, which is typically Mediterranean in character, varies widely in quality and productivity. Because Lebanon is predominantly mountainous, its soil is generally very shallow, fragile and prone to erosion. Even in the Beqaa'a plain, it is rarely more than a few meters deep (UNEP, 2007).

The region's lithology has contributed to the diversification of soil resources, most of which is base-saturated calcareous soil, except for the sandy soil formed on the basal cretaceous strata. The most widely represented types of soil are the Terra-Rossa (red Mediterranean soil) and Rendzinas, which represent about 70% of Lebanese soil (UNEP, 2007).

3.1.2 Climatic conditions in Lebanon

Lebanon falls in the Mediterranean climatic region, which is characterized by a hot, dry summer and a cool, rainy winter; the spring and autumn seasons are short. Topographical variation, however, causes local modifications of the basic climatic pattern, resulting in a number of micro-climates within the country, with contrasting temperatures and rainfall distribution. Conditions vary from a typical Mediterranean climate along the coastal plain and in the Lebanon mountain range to a sub-alpine or mountain Mediterranean climate on the highest peaks, which are covered in snow for most of the year. In some of the Northern plains, the climate is sub-desert in character.

The average annual temperature is 20°C on the coast (ranging from 13°C in winter to 27°C in summer), 16°C in the Beeka valley (ranging from 5°C in winter to 26°C in summer) and less than 10°C at higher elevations in the mountain zones (ranging from 0°C in winter to 18°C in summer). Average annual rainfall is estimated at 823 mm, varying from 600 to 900 mm along the coastal zones to 1 400 mm on the high mountains and decreasing to 400 mm in the Eastern parts and less than 200 mm in the North-East. Above 2 000 m, precipitation is

essentially snowy and helps to sustain a basal supply for about 2 000 springs during the dry period. Rainfall occurs on eighty to ninety days the year, mainly between October and April. About 75% of the annual stream flow occurs in the five-month period from January to May, 16% from June to July and only 9% in the remaining five months from August to December. (UNEP, 2007).

Water is one of Lebanon's most precious resources. Lebanon is in a relatively fortunate hydrological position. It is estimated from isohyetal maps that the yearly precipitation results in an average yearly flow of 8,600 Mm^3. In total, there are about 40 major streams in Lebanon and, based on the hydrographic system, the country can be divided into five regions (Figure1):

- **El Assi** (Orontes**) river basin** in the North that flows into Syria in the North-East of the country.
- **Litani river basin** in the East and South that reaches the sea in the South-West of the country.
- **Hasbani river basin** in the South-East which flows into Israel in the South-East of the country, and is a tributary of the Jordan river.
- All the remaining major coastal river basins as the Northern **El Kebir river basin** is shared with Syria, the river itself forming part of the border between the two countries before flowing into the sea.
- All the remaining small in-between scattered and isolated sub catchments with no noticeable surface stream flow, like the endorheic catchments and isolated coastal 'pockets'.

Lebanon has a relatively favourable position as far as its rainfall and water resources are concerned, but constraints for development consist of the limited water availability during the seven dry summer months. Annual internal renewable water resources are estimated at about 4.8 km^3. Annual surface runoff is estimated at 4.1 km^3 and groundwater recharge at 3.2 km^3 of which 2.5 km^3 constitutes the base flow of the rivers. About 1 km^3 of this flow comes from the ca. 2 000 springs with about 10-15 l/s of average unit yield sustaining a perennial flow for 17 of the total of 40 major streams in the country (Jaber, 1995). Water stress in neighbouring countries including Syria, Jordan, Israel, and Palestine is a harsh reminder that Lebanon must rethink its water strategy in the shortest delay possible, protect water resources and use them more judiciously (MOE-SOER Report, 2001).

3.1.3 Major landscapes in Lebanon

Landscapes in Lebanon are an important factor for the quality of life in a protected environment and of tourist attraction. They represent therefore an economic as well as a social asset. In Lebanon are different remarkable areas as high mountains with different forest, in particular the Lebanon Cedar tree (*Cedrus libani*), nature preserves, areas with high biodiversity and agricultural plains (Figure 2).

Among the most important landscapes of Lebanon, some are visible from a distance such as; peaks (Qornet es-Saouda, Sannine, Barouk, Hermon), are agricultural large plains (Beqaa, Akkar, Koura, etc.), great deep valleys (Abou Moussa, Qadisha, Ibrahim, Litani at Khardali, etc.), picturesque valleys (Jaouz, el- Kalb, Beirut, Barouk – Bisri – Awali, Aassi, Hasbani, etc.), important bays (Jounieh), forests of the North and pine forests of the Cazas of Kesrwan, Baabda, Matn and Jezzine, hills of the South, and the Qaraoun lake (CDR-NPMPLT, 2004).

Lebanon has a rich cultural heritage, which includes a great variety of vernacular architecture, mosques, open air sites, medieval castles, monuments, and sites and general artefacts dating back to the 2nd and 3rd millennium BC. These include the world heritage sites of Baalbek, Sour, Byblos and Anjar, the old cities of Tripoli and Saida, the recently excavated archaeological sites of Beirut, and a number of major historical and/or archaeological sites in urban and rural areas. Considering Lebanon's interest in recovering its role as regional tourism destination, these are the major assets for the tourism industry in Lebanon (CDR-NPMPLT, 2004).

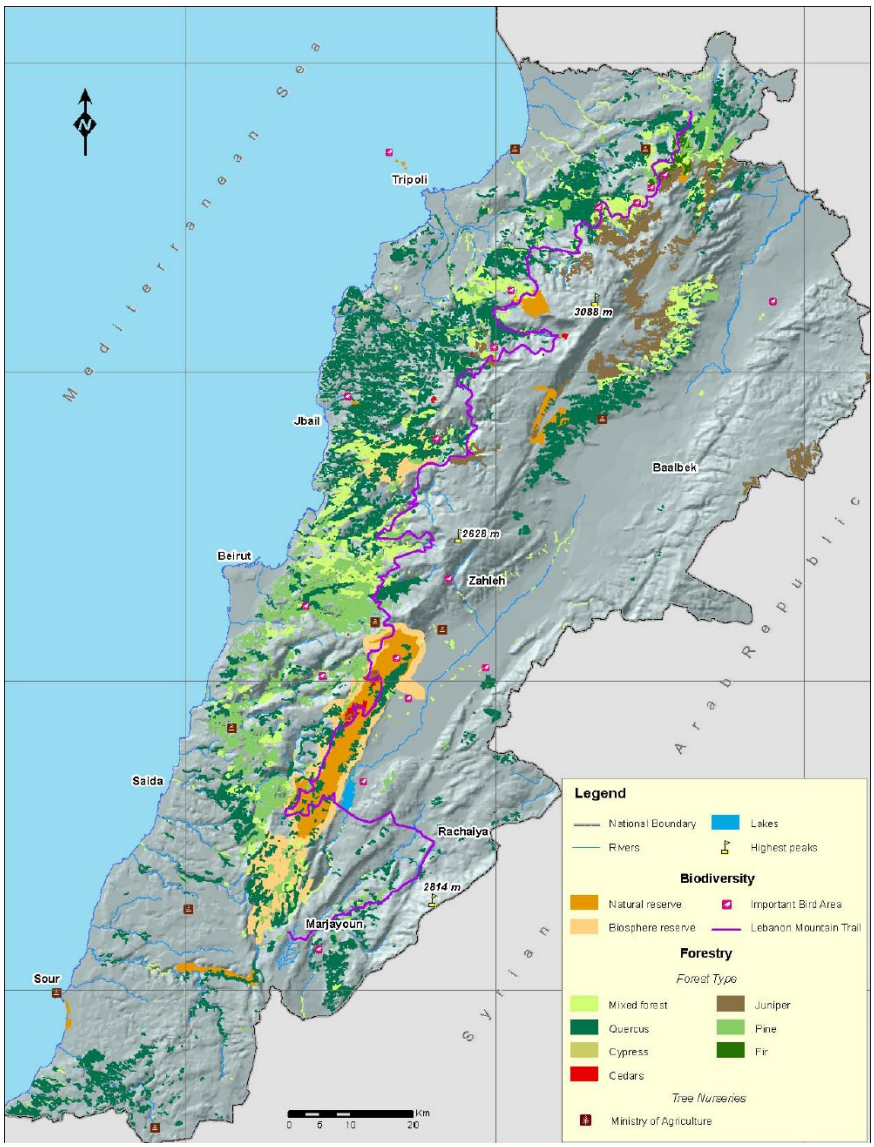


Figure 2 Geographical map of Lebanon with forest cover, natural landmarks and remarkable biodiversity areas (Biodiversity and Forests, 2010)

3.1.4 Biodiversity of flora and agriculture

Lebanon is characterized by its large diversity of ecosystems, due to its variety of environmental conditions (climate, elevation, slope, sun exposure, soil, etc.). A small country as Lebanon has a large diversity of fauna and flora. Relative to its size, Lebanon boasts one of the highest densities of floral diversity in the Mediterranean basin, which in turn is one of the most biologically diverse regions in the world (Médail and Quézel, 1997). Lebanon is provided with exceptional biodiverse conditions that are a great treasure not only for the country, but also to humanity. Preservation and protection of biodiversity is in fact an essential equilibrium for life and nature.

The UNEP report identified 9,119 species in Lebanon, roughly equally distributed between fauna and flora species (Figure 3).

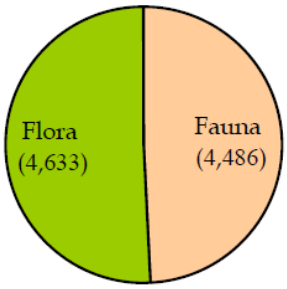


Figure 3 Number of known flora and fauna species in Lebanon (Source MoA/UNEP, 1996a)

This number, however, is believed to represent only 20% of the actual number of species in Lebanon and hence the need to pursue and intensive further research (MoE/UNDP, 1998).

Flora

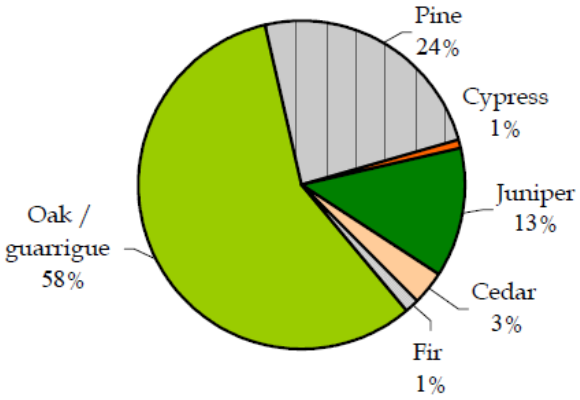
In Lebanon exists a high number of endemic plants owing to its geomorphologic diversity and the isolation effect of its diverse topography. Lebanon has a high percentage of endemic plant species, surpassed only by Turkey in a list of six Mediterranean countries. From a genetic conservation point of view, endemic plants are very important globally because they are only found in restricted regions and therefore harbour unique genetic information that is potentially important to humankind. According to the Biodiversity Reports, approximately 400 plants are endemic to Lebanon, Syria and Palestine, of which 92 are presumed endemic to Lebanon only (MoA/UNEP, 1996c).

The impact of local plant species on Lebanese culture and economy is significant. Many aromatic plant species are extensively used in Lebanese cuisine and many people, mostly in rural areas, still widely use medicinal plants for the treatment of burns, gastrointestinal diseases, and other ailments. A Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) found 224 plants of economic importance distributed in Lebanon (SEPASAL, 1999).

Other economic uses include local consumption (staple foods and wild edible plants), honey production (melliferous plants), landscaping (ornamental plants), and environmental uses (erosion control, agro-forestry, soil remediation, biotic indicators of pollution, etc.).

While such plants are essential to many economic activities, over exploitation is potentially leading to a decline in the natural population of several plant species. For example, wild ornamental plants (and cut flowers such as the narcissus) are being harvested at liberty and perhaps at rates exceeding their rate of natural regeneration.

Several detailed studies have been performed to assess the state of localized forests and forest stands, such as the Rihane mountain region, fruit production in Aarsal, select nature reserves. In the context of a plant cover conservation and management project, the forests of Hadath el Jebbe (Qnat), Jabal Moussa (Nahr Ibrahim) and Kefraya (Bekaa) were also targeted. The basic difficulty in assessing forest resources is the lack of unified forest nomenclature (i.e., canopy closure, forest density and floral associations, state of degradation). Current best estimates of forest cover vary from 4% to 13% (FAO/Khatib, 1996). A precise overview about the current share of major forest species in Lebanon is not available, therefore still the data of 1996 are used (Figure 4).



Source: MoA/UNEP, 1996c

Figure 4 Distribution of forest species in Lebanon (in %)

Agro-biodiversity

Biological diversity also occurs among agricultural crops. The trend nowadays is to adopt more commercial and productive crops, at the expense of more traditional crop varieties. Whereas imported crops usually generate higher yields, traditional crops are incontestably hardier: they exhibit higher drought resistance, sometimes also higher resistance to salt and heat stress, and are less susceptible to pests and diseases. Consequently, traditional crops and wild cultivars, while less productive, require less water and agro-chemicals. Hence there are need to conserve agro-biodiversity, in Lebanon and elsewhere. There are some activities in this regard. An UNDP/GEF (MoE, 2002) project was promoting on-farm conservation management of wild relatives and land races in three areas in the district of Baalbeck (Ham, Maaraboun, and Nabha). To date, it has been conducted eco-botanical surveys, vegetation surveys, indigenous knowledge surveys and implemented a number of small scale activities to improve soil, water and agro-biodiversity conservation of project target crops. To assess the impact of the project activities, 19 sites were selected and delimited using GIS to perform annual monitoring.

The project was also helping to establish a local NGO for development (Nabha) and empowering existing NGOs (Arsal). It has demonstrated to farmers the effect of cleaning and

treating seeds of wild landraces on yields and is evaluating the resistance of several cereal and legume landraces and wild relatives. The project is overseeing the establishment of a gene bank for local grape varieties at LARI, studying micro-propagation techniques for local almond cultivars, exploring the feasibility of expanding honey production, identifying and cataloguing medicinal and aromatic plant, and providing fellowships to university graduates as well as many other activities.

Ornamental landscaping has become an important agri-business in Lebanon. While several retailers acquire their flowers and plants locally, many more rely on imports. Currently, there are no quarantine regulations on imported ornamentals.

Likewise, thousands of trees are imported or donated annually to Lebanon for reforestation campaigns. These stocks are neither certified disease-free nor quarantined.

Furthermore, imported species, such as cedars, could be genetically "contaminating" the native cedar of Lebanon, thus producing new cedar varieties. Such varieties could compete with local species in the long run or attract potentially harmful insects.

In order to mitigate potential threats to local cedar populations, the Ministry of Agriculture has banned the import and introduction of all cedar seeds and plants (ECODIT, 2004)

3.1.5 Protection of habitats and biodiversity

It is developed a national strategy and action plan for biodiversity conservation. This strategy has defined the following nine goals (Ministry of Environment, 1998):

1. To protect Lebanon's terrestrial biodiversity from degradation and ascertain their availability for environmental and economic benefits
2. To conserve freshwater biodiversity through the sustainable management and wise use of freshwater resources
3. To protect Lebanon's coastal and marine biodiversity and develop their resources in a sustainable way
4. To protect Lebanon's agricultural biodiversity from degradation, and secure its availability while maximizing both environmental and economic benefits
5. To conserve biodiversity under natural conditions and establish a balanced ecosystem where plants and animals evolve naturally
6. To conserve biodiversity ex-situ and utilizing existing capacities
7. To protect natural ecosystems from invading species
8. To share global responsibilities in the use, conservation and management of biodiversity
9. To share knowledge, costs and benefits with individuals and communities

A number of areas in Lebanon can be considered to be of global significance for biodiversity as nature reserves occupying approximately 2% of Lebanon's total surface area (ACS-Compendium Statistique National, 2006). Seven are in the focus of protection efforts made at the national level to secure the proper conservation of existing fauna and flora as well as endemic and endangered species:

1. The Al-Shouf Cedar Reserve is made up of three adjacent but separate cedar forests - Ain-Zahalta, Barouk, and Maasir al-Souf
2. The Palm Islands offshore of Tripoli
3. The Horsh Ehden forest
4. The Tannourine Cedars forest
5. The Yammouneh Nature reserve
6. The Bentael Nature reserve
7. The Tyre coast and finally
8. The Ammiq Swamp is of international importance for migrating birds, as the only sizeable wetland between Turkey and Israel; the area is threatened by agricultural intensification.

3.1.6 Situation of Agriculture in Lebanon

The arable land use (Table 1) in Lebanon suffers from lack of appropriate policy, planning and management. The total cultivated area is estimated to be about 250 thousand ha (24% of total land area), of which hundred thousand ha is under irrigation. About 85% of the cultivated land is owned by the private sector. Forests comprise 11% while 45% is classified as not suitable for agriculture *(*MoA/FAO, 2000). Additionally 53,137 hectares were fallow lands abandoned for more than five years. Almost 42% of the exploitable agricultural land is located in the Bekaa, which also accounts for 52% of the total irrigated land. Agriculture is also "losing ground" to rampant urbanization, such as in parts of the Bekaa Valley and the coastal plains.

Elevation levels avail Lebanon of the possibility to develop an extremely diverse agriculture, from quasi-tropical climate in coastal plains up to orchards in high altitude, with a full range of possible intermediary products in between.

Table 1 Land use in Lebanon (MoA/FAO, 2000)

Land Use	Area in ha	% of total area
Cultivated area	248.000	24
Unused cultivated area	137.000	13
Forests	118.000	11
Not arable	473.000	45
Roads, buildings etc.	69.000	7
Total	**1.045.000**	**100**

The major crops grown in the country are fruit trees (29.1%) followed by olives (23%), cereals (21.1%), vegetables (14%) including potato, onions and garlic), nuts (5.7%), industrial crops (4.4%) and grain legumes (2.7%) (Table 2).

Table 2 Area and production of major crops in Lebanon (2001)

Crop	Area cultivated (ha)		Production (tons)	
	Area	%	Amount	%
Cereals	52,000	21.1	172,000	7.5
Grain Legumes	6,600	2.7	61,300	2.6
Industrial Crops	10,900	4.4	30,900	1.3
Vegetables	17,300	7	646,100	28
Tubers, roots, bulbs	17,300	7	428,800	18.5
Fruit Trees	71,800	29.1	858,700	37.1
Olives	56,800	23	85,800	3.7
Nuts	14,100	5.7	29,900	1.3
Total	246,800	100	2,313,500	100

Source: Ministry of Agriculture, 2001

3.1.7 Administrative boundaries and population density

Lebanon is divided into six administrative regions, called *Mohafazas* which are further sub-divided into 25 districts, called Cazas, excluding Beirut (Table 3). Each Caza is made up of several cadastral zones, *manateq iikarieh* as well as villages. In total, there are 1,545 cadastral zones and 1,237 villages. The Bekaa is the largest District (4,161 km^2), followed by the North (2,025 km^2) and Mount Lebanon (1,968 km^2).

Since the last comprehensive population census dates back to 1932, there continues to be no agreement on the actual size of the Lebanese population today. The latest government surveys provided that the population of Lebanon reached in 2005 the number of 3.753.785 individuals (CAS, 1997). Lebanon's population is unevenly distributed, with about 60% clustered in the coastal zone and 31% resident in the Greater Beirut area.

Table 3 Administrative regions and localities at Governorate/*Mohafaza* Level (Compendium Statistique National, 2006)

Mohafaza/Governorate	Number of district	Number of cadastral zones	Number of villages
Beirut	-	12	60
Mount Lebanon	6	507	503
North Lebanon	7	430	252
South Lebanon	3	228	143
Nabatiyeh	4	145	50
Bekaa	5	223	229
Total	**25**	**1,545**	**1,237**

Lebanon is densely populated **(**359 persons/km^2**)**, it is ranked 125th worldwide for its populations and it occupies the 11th position among countries of more than one million people as far as population density (number of inhabitants per km^2) (CAS, 1997).

3.2 The construction sector in Lebanon

3.2.1 Problem statement – need of construction material

The legacy of the war and the accelerated reconstruction process are the major factors shaping the present environmental situation in Lebanon. Major environmental stress in Lebanon is a consequence of poorly managed urban development in residential and non-residential areas, the deteriorating environmental conditions resulting from war-damaged infrastructures, and land and water degradation, due primarily to chaos quarry investments and inadequate management practices. This chapter provides a brief overview of the environmental state of

Lebanon, both in terms of demand for the resource and the major sources of environmental threat and their effects.

Lebanon’s fragile environment combined with long-term anthropic activity has resulted in widespread landscape despoliation. The process has been exacerbated by the civil war and resulting to a breakdown in civil and public authorities.

Among the most Potential Environmental Stresses on Land Resources is the pressure on the quarries caused by continuing construction efforts: removal of sands from the coastal strip has intensified coastal erosion; sand quarrying in mountainous zones has left the steep mountain sides prone to erosion and landslides; exploitation of whit, bluish to whit-greyish clayy, marly-calcareous beds, quarries for cement industries in the northern plain has led to the devastation of olive groves.

Although the ecological impact of rock quarries is localized, their widespread distribution throughout the country makes it necessary to address the problem on a national scale. The high demand for aggregates during the reconstruction program can be met by local resources; however, the increase in demand for sand cannot be met through existing local capacity. Dredging sand from the seabed could have significant impacts on marine ecology, coastal morphology, beaches and fisheries. Furthermore, the seabed might have become a "pollution sink" as a result of the long-term contamination of Lebanon's coastal waters, and any major disturbance of the seabed, such as dredging for sand, could release many contaminants into the marine environment.

Quarries and their pressure exert on natural areas as well as on the quality of life and therefore constitute another major challenge to the environment. Lebanon did not succeed so far in adequately managing this issue. Many quarries are unlicensed, and most of them, even the authorized ones, have not respected legal dispositions in terms of material extraction and site rehabilitation.

Hence, the attitude of the authorities has been divided between the recognition of economic and social importance of quarries, the need to put an end to illegal activities or on the contrary tolerating them, or total and firm prohibition on the entire territory. Prior to the issuance of the decree No. 8803/2002 by the ministry of Environment which was established in 1993, the concerned authorities in Lebanon did not and could not take a definitive decision in approving the quarry master plan, based on which there will be a consent on whether extraction sites should be concentrated in few zones, or on the contrary, distributed on small and medium-sized quarries all over the country.

Hundreds of relatively old quarries in Lebanon have caused a serious visual intrusion to the often spectacular natural landscapes of more than 3,000 hectares of lands. Every year, the needs of the country for raw material would require the use of other additional hectares.

The real damage began in the economic boom years of post-war Lebanon (specifically from 1990 to 2000). The Gross National Product (GNP) annual growth rate for Lebanon between the years 1990-1998 was about 7.2% (UNDP Report, 2000), prompting and prompted by immense and rapid urbanization (and rural-urban migration). Excavation in a chaotic manner answered this quick demand for roads, airport runways, bridges, buildings, ports and other infrastructural provisions (specifically between year 1995 and 1996) with a quick supply. However, the intensive demand for quarrying material does not necessitate chaotic quarrying which is not based on any technical standards; as such demand exists in most other countries around the world that did not resort to such unsustainable quarrying processes. The real reason could be related to local political networks, unprofessional contractors or investor, lack of quarry master plan and to the absence of corrective institutions in the post-war epoch.

Extracting sand and gravel has been a source of conflict between ecologists and developers for over a decade. The proliferation of quarries (old and new) has prompted countless protests by NGOs and conservation groups and calls for halting illegal quarrying activities. In 1995, the GoL commissioned Dar Al Handasah to conduct a national wide assessment of the quarry sector. According to this study, which was issued in year 1996, there were 710 quarries (equivalent to one quarry for every 14.7 km^2) including abandoned and active quarries: 464 limestone quarries and 246 sand quarries. Forty-six percent of all quarries were unlicensed (at the time of the survey) and 71% did not respect the most basic standards and performance criteria (e.g. very steep quarry slopes often exceeding 70º). An estimated 70% of the quarries were structurally unstable and 60% were downright dangerous (Dar Al- Handasah Study, 1996).

The construction sector affects the environment during all stages in the lifetime of buildings: extracting raw materials (quarries, cement production), erecting the buildings (noise, dust, hazardous materials), and using the buildings (disposal of wastewater, energy consumption and emissions), demolition of unwanted buildings. Inadequate construction standards and the lack of sound urban planning regulations further aggravate environmental degradation. Buildings are spread throughout the countryside and growing like mushrooms linearly along roads and highways. Uncontrolled urbanization spoils the landscape and impacts natural heritage.

3.2.2 Pressures on the environment

Buildings consume space and natural resources. They require cement and other building materials, some of them are extracted from quarries (aggregate, sand). The significant pressure on the landscape and the environment concerns essentially sand and gravel, which represent more than 80% of the demands. The needs related to other types of construction (offices, industrial, and commercial facilities) are estimated at 0.5 Mt per year over the same period. According to Lebanon's habits, trends, traditions, practices and culture directly related to the construction sector; all construction works in Lebanon are totally made of concrete or/and aggregate related products. Moreover, the use of face stone to shape the building from outside and internal wall/floor tiling are a very common practice and they will continue to be for the future. It should be taken into account that about 200 to 300 tons of aggregates (sand and gravel) are required to build an apartment. Over the period 2000 to 2030, an annual average between 2 metric tons (lower scenario) and 4 metric tons (higher scenario) of aggregates is required for apartment construction only.

Building materials are hauled long distances exerting pressure on the road network. Finally, the aggregates needed for road construction are estimated at an average of 5,000 tons of aggregates per 1 km of road (double carriage way) construction and 20,000 tons per km of new highway. Ordinary road maintenance consumes around 10% of these values, while rehabilitation can even consume 40%. Hence, if Lebanon's entire road network is to be maintained or rehabilitated only once during the next 25 years and should the network be extended in reasonable proportions, an annual volume of roughly 2 Mt of aggregates is required. During construction, workers are exposed to a wide range of pollutants (particulates) and noise. Nearby residents also are subjected to extensive noise and air pollution.

According the National Master Physical Plan for the Lebanese Territory study in 2004 (NMPPLT), the overall of Lebanon's current demands for aggregates can be estimated as follows: 2 to 4 Mt per year for houses, 0.5 Mt per year for other types of construction and 2 Mt per year for roads. This makes a total quantity in the range of 4.5 and 6.5 Mt per year, or 2 to 2.5 Mm^3. With other extracted materials (calcareous cement, rocks, clay, etc.), the volume to extract – for the Lebanese BTU current needs – could represent up to 3 million m^3 per year (including aggregates) (CDR-NMPPLT, 2004).

If the entire volume were to be provided from local production, the impact of quarries in terms of site disturbances would be significant. In fact, we shall account for the percentage of waste contained in the extracted material and for the land used for storage, circulation, set back, etc. As such, for obtaining 3 Mm^3 of usable material, some 4 Mm^3 should be extracted and the areas required would be 60 to 80 hectare per year. Taking into consideration the rough topography of Lebanon and the high rate of urbanization, a rigorous management policy is required to control the quarrying activities.

Quarries exert significant pressures on the environment. They:

- disrupt the natural landscape and may cause structural damage to nearby houses from blasting
- generate nuisance to nearby populations through noise and dust
- damage or destroy natural habitats and vegetation and underground geologic formations (caves, abysses)
- threaten sensitive ecosystems near natural heritage sites
- induce environmental hazards and risks

Quarries have dealt a serious blow to the once pristine and often spectacular natural and cultural landscape of Lebanon's valleys, gorges, and mountains. According to the Dar el Handasah survey, only three sites (Abu Mizan, Feghal, and Msailha) have some slight sort of restoration work underway, including soil filling and planting. Interestingly (and unfortunately), complaints about landscape degradation are not common; instead residents tend to focus on more direct impacts due to quarrying such as noise and dust (Dar Al-Handasah Study, 1996).

According to the UNDP report on sources of impacts after July war 2006, the impact of quarrying on natural resources was assessed as a major and considerable impact to the environment. The quarrying impact significance was rated as severe for long term duration (the coming 10 to 15 years) (UNDP Country Report, 2006).

3.2.3 Land reclamation, the great consumer of materials

The problem of quarries has emerged in Lebanon with large-scale reconstruction projects during the 1990's. With limited authority control, demand for materials has been significant, ranging between 10 Mm^3 and 15 Mm^3 per year during the period 1994-2000. A considerable part of extracted material (roughly one third) has been used for land reclamation in Greater Beirut (Dbayeh, Beirut Central District, Beirut International Airport runway). This part represents more than 30 Mm^3, which is equivalent to 8 to 10 years of ordinary Lebanese BTP consumption (CDR-NMPPLT, 2004).

Land reclamation projects in Lebanon are frequent and many of them are under study in Tripoli, Jounieh, Jdaydeh, Saida, etc. Additionally dikes and marinas are constructed all along the coastline. Hence, the effect of land reclamation on the proliferation of quarries must be systematically evaluated on both the economic and environmental levels. Scars in the landscapes caused by the quarries left doubt and reservations about the interest, for example, of the Dbayeh land reclamation for offering only 5,000 dwellings, the construction of which would have required 4 to 5 hectares of quarries only (CDR-NMPPLT, 2004).

3.2.4 Population growth and household needs

The growth of house construction is mostly related to increase in the number of households, which increases faster than population size, due to the decrease in the cohabitation phenomenon: with a constant population, the number of households increases because the average size of a household tends to diminish. The average household size in Lebanon was 5.3 persons in 1970. It dropped down to 4.8 persons in 1997. In comparison, this average is still 6.8 persons in Pakistan and 5 in the Philippines, but only 4.7 in Tunisia, 2.4 in France and 2.3 in Quebec. This reduction is due to a higher standard of living change in habits and traditions as well as ageing of the population.

The National Master Physical Plan (CDR-NMPPLT, 2004) adopted a reasonable scenario of a reduction of the average household size at the rate recorded in the past 30 years. Hence, it would drop from 4.76 persons per household in 1997 down to 4.34 in 2020 and 4.21 in 2030 (Table 4).

Table 4 Evolution of household size through 2030 (CDR-NMPPLT, 2004)

	1997	**2030**	**Evolution 1997 – 2030**
Population	4,005,000	5,238,200	+ 31 %
Household size	4.8	4.2	- 13 %
Number of households	843,600	1,321,600	+ 57%

3.3 Quarries in Lebanon: Description and characterization

3.3.1 Types of quarries in Lebanon

While each quarry operation is designed to fit specific deposit, production, and quarry operation conditions and criteria, there are several basic types of quarrying operations to be considered. Normally in Lebanon, crushers are associated to quarries due to their industrial faculty in delivering the end-use product needed for construction purposes. According to available field data (Ministry of Environment list of related decisions to quarrying sector, 1997-2006; Appendix A and B), six different types of quarrying operations are differentiated in Lebanon and are categorized as follows:

1. **Rock quarry** with crusher: for aggregate production (involves stripping, excavation using explosives , processing and trucking) (Figure 5)
2. **Sand, industrial sand and natural aggregates quarry** (mining of unconsolidated materials involves excavation of sand and gravel deposits. It does not require the use of explosives or blasting techniques) (Figure 6).
3. **Mosaic quarry** with small size crusher for the production of the mosaic stone used in the artisanal tiling industry; usually the mosaic quarry is a small sized quarry with small to medium production capacity (involves stripping, excavation using no or little explosives, processing and trucking)
4. **Decorative stone quarry**-without crusher for the production of stone used in the wall and floor tiling (involves stripping, excavation using special diamond floss, trucking (Figure 7)
5. **Cement quarry** without crusher for the cement production (mining of unconsolidated materials involves excavation of material deposits. It does not require the use of explosives)
6. **Crusher without quarry** i.e. for the maintenance of public and private projects (Dams, residential compounds etc.)

In subsequent of Lebanon's mountainous topography and geomorphology as explained in chapter (3.1.2) and due to its small area, only surface mining activities (quarries) are found in Lebanon. Therefore, the scope of our work is to study the surface mines called "Quarries" which are the only existing type of mining in Lebanon although it is well known that other types of mining do exist worldwide such as surface mining (open pits, strip and contour mines, and mountain-top removal), underground mining and sand dredging.

Figure 5 Rock quarry with crusher for aggregate production (current status)

Figure 6 Sand, industrial sand quarry and natural aggregate quarry (current status)

Figure 7 Decorative stone quarry (current status)

3.3.2 Quarries Definitions in Lebanon

The relevant legislation (decree No. 8803/2002 and its amendments) defines **quarries** firstly as all sites from which materials are extracted but which are not covered under the umbrella of mining legislation. Secondly, quarries are defined to aim at the production of materials for commercial or industrial purposes. Therefore, quarries do not include sites where excavation for urban development purposes takes place (Decree No. 8803/2002 and its amendments). **Surface mines** include quarries comprising a few hectares.

In Lebanon it is more common to use the word quarries than mines since we do not have other type of mining activities or operation except sand dredging which does not fall in the scope of this study. These operations require total disruption of the project area with large quarry(ies) and extensive overburden piles; however, it is often feasible to backfill the mined areas during or at the end of operations. Other land uses at the site are precluded during the mining and reclamation activities. Slope or bench stability is a major concern in surface mining. Good mining practice requires constant observation for bench face movement that might indicate impending slope failure (World Bank, 1991).

3.3.3 Mining operations

Stripping is the initial step in the mining operation and involves removal of topsoil and sub-soil that covers mineable materials. A variety of equipment is used to strip, transport and re-deposit sub-soil (Bauer, 2000).

Excavating equipment and procedures also vary with each operation. For purposes of clarification, excavation operations are described by mine type and more specifically for the two main categories: Stone quarry and sand quarry (Bauer, 2000).

1) Stone quarries: Excavation of quarry material involves a three-step process. The first step is to break the stone away from the quarry wall and break the stone into small pieces. This is accomplished by the use of explosives. Holes are drilled behind the quarry wall (cut face) within which explosive charges are placed. Depending on the deposit depth, a standard procedure is to create a series of terraces or "benches". The second step is to excavate broken stone by either front-end loaders or any other similar types of excavations equipment. The third step is to transport broken stone to the processing plant.
2) Sand and natural aggregates quarries: Sand and natural aggregates excavation is a two-step process. No blasting is required in this type of mining. The first step is to excavate the material/deposit by using the appropriate type of excavators. The second step is transport-excavated material to the segregating plant. In Lebanon very few are the sand quarries which are associated with washing plants to remove impurities from the sand product

Processing plant is the heart of a mining operation.

- For the stone quarries: produces products that meet a variety of product specifications for the construction industry. A typical plant includes crusher used to reduce the size of stone, screens that segregate the stone and sand into various sizes, wash plants that remove various impurities, such as clay and dirt, conveyor belts that transport the stone and sand to various parts of the plant, stackers that deposit each product into a separate stockpile, and load-out facilities for transporting products to the construction site.
- For the sand quarries: includes a big sieve that screen the excavated material and segregate it into different types, grades and form the impurities.
- Support facilities: are located in close proximity to the processing plant. They include maintenance areas, equipment and supply storage areas, a scale house and offices. Normally, the scale house and office are located near the entrance between the public road and the processing plant.

Trucking is the primary means of transporting construction aggregates to the market. Typical concerns rose by local citizens and officials include excessive wear on local roads, increased traffic, safety, dust, and impact on property values (Bauer, 2000).

3.3.4 Types and distribution of operational and non-operational quarries

Quarries are widespread over the Lebanon region and their geographical distribution is attributed to the local geology of the area. For example, the location of the majority of the quarries used to extract aggregates and rock from rock quarries is mainly in formations of the Cenomanian Age-C_4 (Cretaceous Period) and of Jurassic Period. Sand quarries are mainly located in formations of the Neocomian Age-C_1 (Cretaceous Period). The geographical and geological distributions of quarries have led to the distribution of related industries and their clustering around such areas. For example, cement factories are located in areas where marly formations are available.

Rock Quarries are divided into two types: quarries where rock blocks are extracted and quarries where rocks are extracted and crushed into aggregates. Table 5 presents the geographical distribution of operational rock quarries.

Table 5 Distribution of rock quarries in the districts (Dar Al-Handasah Study, 1996)

Governorate	No of operational rock quarries		Total
	Aggregates	Rock	
Bekaa	33	85	118
Mount Lebanon	17	97	114
North Lebanon	20	72	92
South Lebanon	2	35	37
Total	**72**	**289**	**361**

Sand Quarries are quarries where direct extraction (no blasting) of sand takes place. Few sand quarries, however, contain washing basins to improve the material gradation. Table 6 presents the geographical distribution of operational sand quarries.

Table 6 Distribution of sand quarries in the Governorate (Dar Al-Handasah Study, 1996)

Governorate	No of sand quarries
Bekaa	3
Mount Lebanon	126
North Lebanon	32
South Lebanon	28
Total	**189**

Since the site survey was mostly carried out for rock quarries, the total number of sand quarries is mainly based on the revised official records and is not inclusive of all sand quarries in Lebanon.

Non-Operational Quarries or abandoned rock or sand extraction sites are 160 out of the 710 quarries in Lebanon. The abandoning of such quarries may be due to several reasons such as:

- the quarry has reached to the property limits, or
- the quarry was operating without a license and was closed by the government.

The geographical distribution of non-operational rock and sand quarries is concentrated in the district Mount Lebanon (Table 7).

Table 7 Distribution of quarries in the governorate (Dar Al-Handasah Study, 1996)

Governorate	No of Non–Operational Quarries (Rock and Sand)
Bekaa	2
Mount Lebanon	127
North Lebanon	30
South Lebanon	1
Total	**160**

3.3.5 Distribution of all types of quarries in Lebanon

In result of the survey regarding the geographical distribution of quarries in Lebanon by Dar Al-Handasah, is visible the high number of non-operational quarries in comparison to the operational ones (Table 8).

Table 8 Distribution of all quarries in the districts (Dar Al-Handasah Study, 1996; Ministry of Environment, 2007)

Governorate	Number of Quarries		Total (1996)	Total (only operational) (2007)
	Non – Operational	Operational		
Bekaa	2	121	123	53
Mount Lebanon	127	240	367	212
North Lebanon	30	124	154	117
South Lebanon	1	65	66	90
Total	**160**	**550**	**710**	**472**

It is remarkably 51.7% of the total number of quarries in Lebanon is clustered in Mount Lebanon, followed by 21.7% and 17.3% in North Lebanon and the Bekaa respectively, and only 9.3% in South Lebanon. The abandoned quarries, however, constitute 22.5% of the total number of quarries in Lebanon with the largest number of abandoned quarries located in Mount Lebanon. Newer data from the Ministry of Environment from 2007 is showing that the

number of quarries in Lebanon is already reduced a little. On the other hand the numbers of quarries in South Lebanon increased.

The Dar Al-Handasah Study (1996) indicated that some 62% of rock quarries in Lebanon are considered to be small size quarries and the remaining 38% are divided equally between medium to large quarries (Table 9). Nevertheless the problems during their use and also regarding their renaturation are similar.

Table 9 Distribution of quarries per quarry size (Dar Al-Handasah Study, 1996)

Quarry size	Volume extracted in m^3	Percentage of rock quarries
Small	< 15 000 m^3	61.6
Medium size	15 000 m^3 - 40 000 m^3	18.6
Large quarry	>40 000 m^3	19.8

The combined excavation volume in 1995 was estimated at 24.4 Mm^3.

Evaluating the ways of operating in the quarry sector there are many problems. More than 30 percent of the aggregates originated from unlicensed quarries. Mount Lebanon was by far the largest producer of aggregates (45.6%) and North Lebanon hosted the largest number of unlicensed quarries, producing almost 61% of the total volume of aggregates originating from unlicensed quarries. By operating the quarries were destroyed spectacular natural and cultural landscape of Lebanon's valleys, gorges, and mountains. Quarries at Msailha (Batroun), Nahr Ibrahim, Nahr el Kalb, and Nahr el Mott are such examples. According to the Dar el Handasah survey, only three sites (Abu Mizan, Feghal, and Msailha) have a little restoration work underway, including soil filling and planting (Dar Al-Handasah Study, 1996).

But not only the capacity of quarries is from economically interest, also the type of material which can be excavated (Table 8). It is evidently that the rock quarries have highest percentage followed by the sand quarry. Although the lowest percentage rate is for the cement quarry sector but it is worth mentioning that in cement quarry sector, the area of investment is the biggest per quarry.

Table 10 Distribution of quarries per type of material (Ministry of Environment, 2007)

Type of material	Number	Percentage
Decorative stone quarry	92	19.4
Cement quarry	8	1.6
Rock quarry with crusher	163	34.5
Mosaic quarry	27	5.7
Sand and natural aggregates	65	13.7
Sand for industry	117	24.7
Total	**472**	**100**

3.3.6 Legal framework: Environmental Management

3.3.6.1 Overview and background

The Lebanese constitution did not state explicitly to protect the environment. However, Lebanon commit and respect the national policy of human rights according to the United Nation treaty dated 25 of September 1945 (The Lebanese constitution, 1943).

In addition, the present President of Republic in his oath statement declared that environmental criminalities should not continue (Personal communication, 2008). On the other hand and since year 2000, the consecutive governments affirmed in their government policy statements, that environment is ranked on the top list of their high priorities. They confirmed in their policy statements too, that an extra effort should be done in order to enforce and implement the existing regulations and set up new laws and regulation to ensure proper preservation of the environment and its natural resource for the public interest ensuring its sustainability for the upcoming generations (Government of Lebanon Policy statements between 2000 to 2005).

<u>The Institutional Framework</u>

A number of institutions in Lebanon have direct or indirect involvement in environmental management, in particular the Ministry of Environment (MOE), various line ministries, research and academic organizations, and NGOs. However, as is prevalent throughout the public sector, and because of the war impacts, major disruptions occurred both in administrative structure and in human resource endowment.

The Legal Framework

Lebanon has a large body of environmental laws, some dating back to the 1930's. However, these laws are characterized by: (i) obsolescence and the need for updating; (ii) lack of clarity regarding accountability for implementation; (iii) lack of coherence, as some legislation was hastily passed without taking into account pre-existing legislation; (iv) lack of provisions of mechanisms for implementation; and (v) general weakness of law enforcement due to lack of clarity in responsibilities and coordination and insufficient deterrent value.

According to an assessment of environmental management systems in developing countries (Lovei, 1994), in Lebanon the environmental management system itself de facto remains fragmented, although a separate environmental protection agency is established and administrative functions and resources for environmental management are transferred to this agency. The reason is many tasks related to environmental protection are still in the hand of other ministries. So, it is fact that some ministries (public works and transport, Agriculture, energy and water, Public Health, Industry and CDR) still keep control over some environmental management issues.

Referring back to the legal framework managing the quarry sector and in order to better understand the past and present situation, a thorough review was done for all quarries relevant legislation since year 1930 until present date. This review indicated that 79 references were related to this topic. A brief of these legislative references is illustrated in *Appendix A*

The *Appendix A* lists the several national institutions involved in this in the management process of this sector each at its level of authorities including the council of Ministers as the highest executive authority in Lebanon as per Ta'ef agreement after the Lebanese civil war.

3.3.6.2 Environmental Institution in Lebanon

The Ministry of Environment (MoE) created in 1993 by the law 216 with the power to: (i) formulate general environmental policy and propose measures for its implementation in coordination with other concerned agencies; (ii) protect the natural and man-made environment in the interests of public health and welfare; and (iii) control and prevent pollution, irrespective of the source. Although law 216 gives the MOE a broad mandate over environmental issues, it is the source of ambiguities in the areas of policy formulation (overlap with other agencies and lack of provision for a unit or body to carry out this task), the policy and executing roles of the MOE, and the lack of a clear definition of what constitutes violations in the mandated fight against pollution. Although the monitoring function is given to the MOE, enforcement powers lie within the prerogatives of the Ministry of the Interior and municipalities.

Since the Ministry is not an implementing agency the financial resources allocated for the Ministry of Environment in the 2005 national budget plan was approximately 2.6 million

US$, representing 0.05% of total budgetary expenditures, 1.98 million US$ in year 2006 and 2.14 million US$ in year 2007 respectively (Government of Lebanon budget plan, 2005, 2006 and 2007).

The Ministry employs about 58 highly qualified public servants; levels provided are such that the MOE's capacity for environmental management is very limited (UNDP-Capacity 21 Project Final Report, 1996). This number accounts for less than 40% of its posts, which places a tremendous load on the resources to manage the day-to-day issues, and thus leaves less time for planning and programming. It is to be noted that the number of ministry expertise is subject to potential decrease due to the economic situation of the country.

After it's initiation in 1993 by law 216, the Ministry of Environment considered two amendments to its existing mandate law in order to better outline and govern the environmental sector as well as to eliminate the overlap with other concerned ministries through clear separation of tasks and responsibilities and accountability. Its mandate was first revised in 1997 by law No 667 and secondly in year 2005 by law number 690.

3.3.6.3 Organizational chart of the Ministry of Environment

As explained previously, MOE is currently organized into one Directorate General and six services according to decrees No 5591/94 and 667/97. It currently holds the following administrative structure as shown in Figure 8. It is to be noted that the Service of Regional Offices and Environmental Police not established yet.

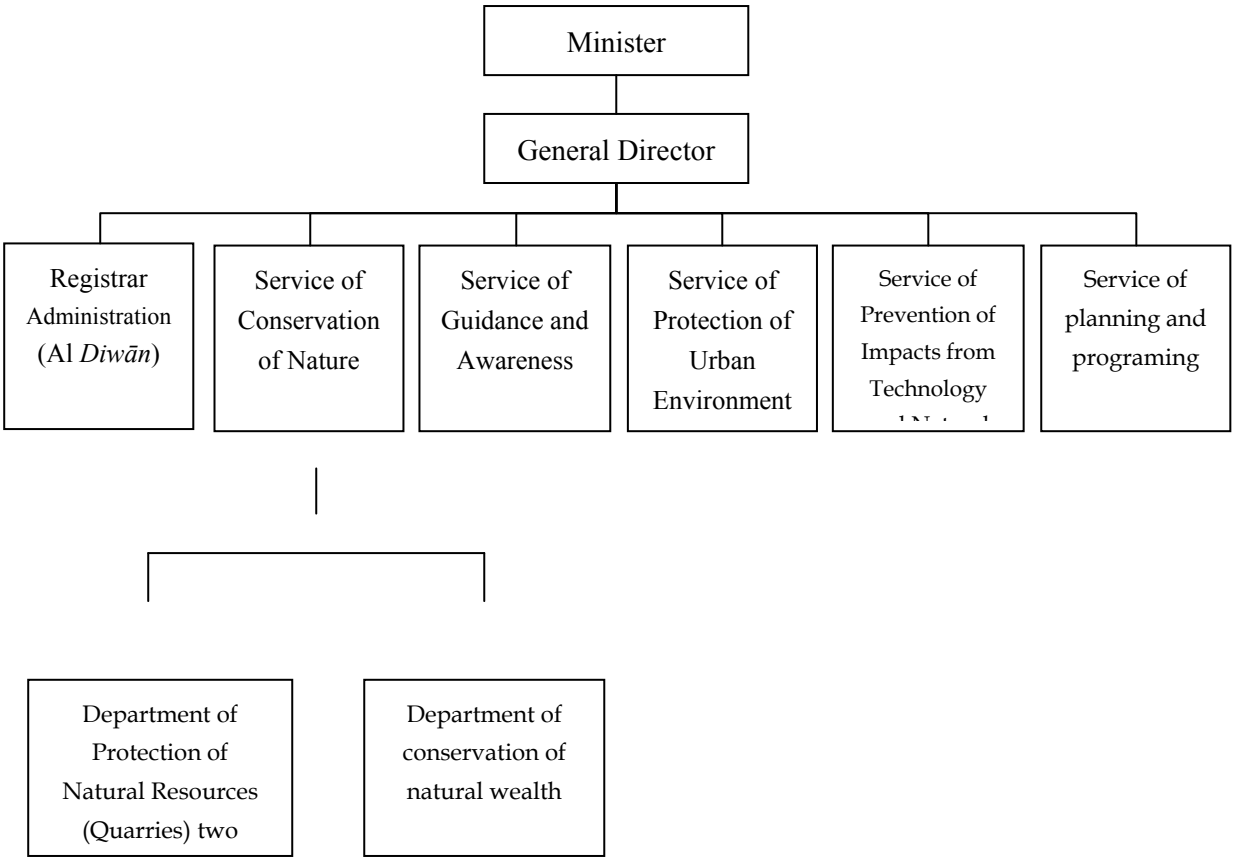


Figure 8 Current organizational chart of the Ministry of Environment (MOE-SOER, 2001)

The Ministry attempts managing the environment and its natural resources in a participatory approach with all stakeholders (academia, non-governmental non-profit community based organizations, private sector, public sector, mass media, and international organizations) according to five major principal policy pillars.

1. Sustainable Ecological Development
2. Protection Through Prevention
3. Polluter Pays Principle
4. National Equitable Development
5. Mainstreaming of Environmental Policy

The Ministry is currently working on developing it mission statement.

3.3.6.4 Legislative profile

There is a considerable volume of laws and regulations on environmental issues in Lebanese legislation. They have all been integrated in a number of draft legislation, which are all in the pipeline for enactment. This major national program of environmental legislation is a priority matter and is aiming at making the legislative framework more transparent and user friendly for the Lebanese citizen and overseas tourist and investor with respect to abiding with

environmental legislation. Lebanon is signatory to most if not all relevant international environmental conventions, treaties, protocols etc…

The Parliamentarian Committee for Environment is the very newly recognized Committees in the Lebanese Parliament. It was first established in year 2000 and includes among its permanent members 12 parliamentarians. Many government agencies have environmental responsibilities, sometimes this can awoke problems in decision making, in particular regarding the management in the quarry sector (Table 11).

Table 11 Governmental institutions with environmental responsibilities (MoE, 2002)

National Council for Quarries include members	Other institutions of related mandate
• Ministry of Environment – • Ministry of Public Works & Transport - directorate general of urban planning • Ministry of Interior and Municipalities - directorate general of administrations and local councils • Ministry of Energy and Water • Ministry of Public Health • Ministry of Defense • Ministry of Finance • Ministry of Agriculture- directorate of rural development • Ministry of Culture - directorate general of archeology	• Ministry of Industry; • Council for development and reconstruction

3.3.6.5 Overview on quarry licensing procedures

Presently there are two way to operate a quarry in Lebanon: the proper permitting procedure and the administrative extension authorization.

<u>The permitting procedure</u>

In order to operate a quarry, a license (permit) is needed for this purpose. This procedure involves the submission of an application to ensure compliance to the technical standards and administrative requirements established by the National Council for Quarries created by the

decree No. 9222/2002. The above mentioned council is headed by the Minister of Environment and includes representatives from eight other line ministries and government institutions already listed in Table 11.

The initiation of the process requires a submission of 3 copies of a request file from the proponent to the related Governorate according to cadastral area where the quarry is going to be established. In addition to basic information (personal details, details of land ownership, site plan, municipality council approval…), the application must especially include the major following documents:

- The nature and volume of the activities which the applicant proposes to undertake;
- The quarrying process which the applicant will employ, the materials which he will use;
- A map indicating the localization of the project and a more detailed map (1/2000) indicating the boundary of the quarry, the roads, the buildings;
- All related maps: topography, geology, rehabilitations;
- An impact notice on how the envisaged work will probably affect the environment;
- Other relevant documents.

After reviewing the application file for completeness according to prepared checklists for each type of investment operation, a site visit by the technical team of the ministry of environment staff is done to investigate the site and do the necessary measurements and observations. *Appendix B* indicates criteria set by the ministry of environment for each type of investment.

Then, according to the authority stated in the decree No. 8803/2002 and its related amendments, the procedure is split into two:

1) Investment of rock and sand quarries outside the 4 areas indicated in the decree: the council of Ministers is the authority to take the decision on approving or disapproving the application. The National council for quarries at its regular meeting forwards this kind of application files and their technical reports to the council of Ministers to take the appropriate decision. It is worth mentioning that no decision had been taken until present date by the council of Ministers regarding the forwarded applications (Decree No. 8803/2002).

2) Investment of rock and industrial sand quarries and other types of investment all over the Lebanese territory: the National Council for Quarries headed by the Minister of Environment is the authority to take the decision (Decree No. 8803/2002).

At the meeting the MOE staff presents the application file and its technical report to the national council of quarries who may approve or disapprove or request more in depth information and may in some cases refer the file to another party for further processing.

Once the National Council for Quarries approves, the Minister of Environment as head of the council sends the approval decision to the correspondent/concerned Mohafaza to issue the operation license (permit).

In case of approval by the National Council for Quarries, a financial bound is therefore required to guarantee that rehabilitation plan will take place according to the application approved by the relevant authorities. These guarantees or bonds would be returned the operator/investor only if the site has been satisfactorily rehabilitated. If rehabilitation is not executed or completed properly, part or all of the bond amount (or guarantee) may be confiscated and used to complete the rehabilitation work. With respect to bond amount, the most recent estimates include (MoE decisions related to quarries listed in Appendix B):

- Stone quarry: 4,500 LBP (3US$) per m^3 extracted;
- Mosaic Quarry: 6,000 LBP (4US$) per m^3 extracted;
- Decorative stone/construction block quarry: LBP 9,000 (6US$)per m^3 extracted;
- Cement Quarry: 9,000 LBP (6US$) per m^3 extracted;
- Sand Quarry: 6,000 LBP (4US$) per m^3 extracted.

In general, the license's duration is for one year subject to renewal in case the proponent abides during his operation all rules and regulations and all environmental conditions stated in his license. This requires too the submission of the renewal application to the Governorate/Mohafaza in order to complete the whole process in the same way of getting the first license.

Since December 2002 to end 2008, the national council for quarries in 25 consecutive meetings *(Appendix C)* issued 59 approvals regarding several types of investments. On the other hand, the MOIM had, upon approval of the council of Ministers decisions, issued 449 administrative extension in year 2006, 490 in year 2007 and 210 until Midyear 2008 (*Appendix D*).

The administrative extension procedure

The "administrative extensions" authorization procedure is in principle a delay with a limited period given by the *Mohafez f*or the classified enterprises to be compliant with rules and regulations. The majority of the quarries in Lebanon are operating under this procedure upon the approval of the Council of Ministers consecutive decisions (Kindly refer to Appendix A). Usually not based on neither proper administrative, financial and institutional nor technical criteria, these administrative extension constitutes a shortcuts bypassing the law allowing the investors to work almost anywhere for a short period (three months each time subject for renewal) without respecting environmental conditions or financial deposit and charges or rehabilitation practices;

3.3.6.6 Current Charges and Financial Guarantees

The Lebanese government already imposes significant charges on quarry operators, albeit it is a well-known fact that much of the listed charges by law are not paid in actuality. Furthermore, as most of the quarries that have operated in the past (and currently operating under administrative extension authorization) have done so without acquiring the appropriate permit, no financial guarantees were placed up front.

Nevertheless, the Ministry of Finance (under its 2003 Budget Law) is the first that charges quarry operators through or upon issuance of a required permit, a lump sum of LL 2.5 million, (1.666 US$) and an additional fee of 1,000 LBP for every m^3 excavated (US 0.66 cents/ m^3), paid on a monthly basis (Ministry of Finance, Budget law, 2003).

Municipalities also have a right to charge an annual fee on licensed quarries operating within their jurisdiction amounting to (upon license and in Lebanese Pounds) (Minster of Finance decision No. 1109/1 date 16/07/2003);

1. Stone quarry: 15,000 LBP (10US$) per m² area
2. Mosaic Quarry: 20,000 LBP (13.5US$) per m² area
3. Decorative stone/construction block quarry: 20,000 LBP (13.5US$) per m² area
4. Cement Quarry: 30,000 LBP (20US$) per m² area
5. Sand Quarry: 20,000 LBP (13.5US$) per m² area

In respect to the use of Economic Instruments**,** Lebanon is attempting to apply a set of regulatory and economic instruments to achieve environmental compliance. The permitting and land use regulations are very weakly enforced due to the previously discussed problems of institutional weakness, responsibilities overlap, and lack of clarity in the laws. The reconstruction and recovery programs concentrate heavily on physical infrastructure with no systematic requirement for environmental impact assessment.

3.4 Review of quarry management in selected countries - France, Great Britain, Tunisia, Canada (Quebec) and Malta -

The countries and states selected for the study review of international quarry management were chosen in such a way that each study satisfies at least one of the following criteria:

- Highly developed and elaborate quarry management and legislation
- Similar legal system to that of Lebanon (Civil Law)
- Similar environment to that of Lebanon (cultural, location, climate…)
- Diversity of case study, and
- Other criteria such as language and accessibility of legislation

Accordingly, the five selected countries (and states) comprise France, the United Kingdom (Great Britain), Tunisia, State of Québec (Canada) and Malta. Since in the United Kingdom laws are generally shared amongst its various members (Scotland, Wales, North Ireland, and Isle of Man) with minor specifications peculiar to each, only English Law shall be considered in this review.

The case of Malta was particularly interesting due to its recently drafted quarry legislation its unique approach to planning, as well as the familiar constraints this sector shares with Lebanon. For example, similar to Lebanon, effective enforcement and monitoring are major barriers to the quarry sector in Malta. To illustrate, in August 2001, the Maltese Resources Authority (MRA) revealed that, among the 94 stone quarry sites of the country - abandoned or running -, over 60 % of quarries had gone beyond the boundary stipulated by their permit or were operating without a permit. Moreover, an overview of the case studies proves that different legislations adopt different approaches to the matter of quarries. Great Britain and Malta in particular have stressed on regulations which are goal setting, rather than prescriptive.

The difference of legal system shall also be emphasized. The law in Great Britain, and Malta, is technically based, for the most part, on English common law concepts and legal organizational methods which assign a pre-eminent position to case-law, as opposed to legislation. Whenever a judge makes a decision, this decision becomes a precedent: a rule that will guide judges in making subsequent decisions in similar cases.

France, Québec, and Tunisia have a civil-law tradition, based on Roman law. The law, in these countries, contains a comprehensive statement of rules, many of which are framed as broad, general principles, to deal with any dispute that may arise. Unlike common-law courts, courts in a civil-law system first look to the Code, and then refer to previous decisions for consistency.

However, in public law, as health or environmental law, this distinction has become blurred as even the countries of common law tradition have resorted to written law.

3.4.1 Definitions and classification of quarries in the reviewed countries

Type of quarries

The relevant legislation of all the selected countries defines quarries firstly as all sites from which materials are extracted. These are not covered under the umbrella of mining legislation. Secondly, quarries are defined to aim at the production of materials for commercial or industrial purposes. Therefore, quarries do not include sites where excavation for urban development purposes takes place. Finally, in all five countries selected for this review, the term quarries includes not only the sites for the extraction of consolidated rock, but also sites where other materials are extracted including: limestone, granite, slate, marble, gypsum, marl, gravel, loam, sand, clay.

In France (French Decree No. 77-1133. 1977) and UK (British Quarries Regulations, 1999) the definition of quarry extends to include the following components: buildings, tips, processing sites, mineral storage areas and other associated infrastructure of a quarrying site, so long as the mineral is being produced.

The **Tunisian** legislation makes two other distinctions. On the one hand, it distinguishes open cast (surface) quarries from underground quarries, whereby underground quarries are subject to the provisions of the mining industry. On the other hand, the Tunisian legislation also distinguishes quarries used for craft purposes from those of industrial function (Tunisian Law No. 89-20, 1989)

A similar distinction can be found in the **French** legislation where quarries operated by farmers or by municipalities are subject to special provisions (French Decree No. 2002-680, 2002 and Law No. 2005-157, art. 42, 2005).

The **Quebec** regulation solely authorizes open air quarries (Canada-Quebec Regulation respecting pits and quarries, art. 1. No date specified)

Size of quarries

Thresholds vary according to the considered country:

In **France**, all quarrying activities are subject to quarry legislation with two exceptions (French Ordinance, 2002 and French "Circulaire", 2003):

- Dredging activities with less than 2000 tons of dredged material;
- Chalk marl or clay extractions when the operator is either a farmer or a municipality for their own use, and when the extraction surface is lower than 500 m², the extracted materials amount lower than 250 tons per year, and the total extracted materials amount to less than 1000 tons.

Moreover, in **France** all quarries have to be authorized through the proper authorization channels except in the cases listed below, which are subject to a softer system- the declaration system (French Ordinance, 2002 and French "Circulaire", 2003):

- Rock, sand, and clay quarries of small extent addressed to historical monuments restoration when the patrimonial or architectural interest justifies the restoration to be carried out with the original materials.
- Chalk marl and clay extractions when the operator is either a farmer or a municipality for their own use -that is to say to improve the soil texture and acidity rate for a farmer, and to rebuild local paths for a municipality. Some of them could be 50 meters deep and have a 4.500 m^3 volume.

In **Tunisia**, all underground quarries are governed by the country's national Quarry Law, while open cast (surface) quarries are subject to the Quarries Law only under certain conditions (Tunisian Order on quarries operation art.1., 1990):

- If the quarry consumes over 2,500 kg of 2^{nd} class explosives a year (e.g. nitroglycerin) or 5,000 kg of 3^{rd} class explosives a year (made up with ammonia or potassium nitrate); or,
- If the production capacity exceeds 5,000 tons a year for clay quarries or 70,000 tons a year for other materials; or,
- If the quarry uses peculiar extraction process as dredging or sawing; or,
- If the quarry was classified as a quarry submitted to the Quarries Law by the Quarries Consultative Council in regard to its environmental impacts.

In **Great Britain**, **Québec,** and **Malta**, all quarrying activity is subject to the quarry legislation and therefore requires a permit. In Québec however, extraction from a natural deposit of unconsolidated mineral substances for the building, rebuilding, or maintenance of logging or mining roads is not submitted to a quarrying permit (Canada-Quebec Regulation respecting pits and quarries, art. 58. No date is specified).

3.4.2 Planning of quarries

Planning for the mineral extraction industry consists of answering the questions of "where?", "how much?" and even "whether?" to extract minerals with the long-term view in mind.

Tunisia and **Québec** have no national or regional planning system, but rely solely on local planning. It is prohibited to establish a new pit or quarry in a territory zoned by the municipal authorities for residential, commercial, or mixed purposes (commercial-residential). In **Québec** however, the Ministry of the Environment listed in its Decree, eight (8) territories of designated landscape, nature conservation, or heritage value where it is prohibited to undertake the operation of a pit or quarry (Canada-Quebec Regulation respecting pits and quarries, art. 57. No date is specified).

In **Great Britain**, **France**, and **Malta**, national or regional land-use planning for minerals is adopted. It generally consists of two levels, or three in the case of Great Britain. Moreover, the planning activities are based on the following principles:

- Minerals should be conserved, as far as possible, whilst securing an adequate supply to meet the needs of the economy and society.
- Environmental impacts caused by mineral operations and the transport of minerals should be kept to an acceptable minimum through good operational and management practices.
- Restoration of sites should preserve or enhance the overall quality of the environment after working has ceased and, where appropriate, make contributions to improved habitats and biodiversity.
- Areas of designated landscape, nature conservation or heritage value should be protected, as far as possible, from mineral development.
- The unnecessary sterilizing of mineral resources by using the land permanently for other purposes should be avoided.

The **French** planning system for quarries consists of both local planning at the municipal level, and regional planning at the "Département" level. At the local level, each municipal council has to put in place a Local Plan Policy (PLU) (French Code of Urbanisme art. L. 123-1.), that indicates the zones that are destined for residential, commercial, industrial, agriculture development and the zones that are destined to remain "unbuildable." It indicates thus the zones where quarrying activities are allowed. At the department level, a Departmental Quarries Plan defines the general conditions for the working of quarries in the department and sets objectives for rehabilitating and redeveloping sites (French Law No. 76-663, July 19th, 1976).

It takes into account:

- National economic interests,
- Resources and requirements for materials in the department and neighboring departments,
- Protection of landscapes, sites and sensitive natural environments, and
- The need for balanced land management, while encouraging the economic use of raw materials.

The departmental quarries plan is drawn up by a Departmental Quarries Council and, following the approval of the representative of the State in the department - the Prefect ("Préfet"), it is published. The authority that grants or denies the permit is the Prefect.

The complexity of the system stems from the fact that the authorization for quarry operation must be consistent with the Departmental Planning as well as the Local Plan Policy. The Prefect can thus deny a permit that was granted by local authority if directions show for example that there are already many quarries of the same materials in the area; an act which is usually prohibited by Departmental Quarries Plans. The Prefect may also, even without any quarry application, use the Interest Project Process, provided in the Town-planning Code, to modify the Local Plan Policy. On the contrary, the Prefect may authorize a quarry in a zone where the local plan prevents quarries if its opening is essential to carry out the departmental plan objectives. To that end, the prefect can resort to the above mentioned Interest Project Process (French Administrative Directive, 1995).

Malta has also developed a two level planning system for its quarry sector. In 2002, the Malta Environment & Planning Authority (MEPA) launched a national Minerals Subject Plan, which covers a ten-year period from 2000 to 2010. At a local level, the Maltese Islands are covered by seven (7) local plan areas aiming at elaborating the national policy and providing more detailed guidance. In a Local Plan, for example, a policy can relate to quarrying expansion and identify areas for future quarrying.

The first national minerals policy was contained within the Structure Plan for the Maltese Islands (1990) aiming at protecting the environment, ensuring adequate supply of minerals as well as a avoiding their depletion. However, this first plan did not grant sufficient means for the control authorities to assume effective enforcement of the national policies.

Adopted in 2002, the newly established Minerals Subject Plan aimed at:

- Effective monitoring of license and permit conditions;
- Better Control of the impacts of extraction, including protection of important landscapes and sites;
- Provision of a comprehensive framework for the future supply of minerals;

- Management of inevitable land use conflicts between quarrying industry, tourism, residential development and the preservation of natural and cultural resources.

The MEPA drew up the plan in consideration with international policy and regulations, particularly those of the European Community, in view of the potential accession of the Maltese Islands.

The plan considered many means of action in a step-by-step gait:

- Define the needs and the issues: production and resources evaluation to facilitate a more accurate assessment of demand; census of abandoned, existing and potential sites (establishment of databases)
- Planning and zoning: make sure that local land use policies comply with the Minerals Subject Plan, protect scheduled sites
- Improve the regulations enforcement: regulate non-authorized quarrying activities, restore abandoned quarries, develop control methods
- Improve on current practice: increase the contribution of alternative supplies, particularly through the recycling of inert construction, demolition, and quarry wastes, diffusion of a *Code of Practice for Quarry Working and Restoration* that provides helpful guidance on the details of site restoration

The MEPA first undertook research to better establish a database on production and reserves and it was concluded that there was an adequate supply of minerals for the Plan period and beyond. For this reason, the MEPA decided to presume against the development of any new quarries for a period of around 5 years until the database will have been improved. A framework is meanwhile put in place to guide quarry extensions.

The Minerals Subject Plan also provides a framework for protecting sites of nature conservation importance. Since 1991, 23 specific Nature Reserves have been designated. Scheduling of Areas of Ecological Importance (AEIs) and Sites of Scientific Importance (SSI's) began in 1994: AEI's include areas of both typical and rare habitats (permanent springs, watercourses, typical coastal zones, forest remnants, valley sides, deep natural caves…); SSI's contain individual species, groups of species and geological features of particular scientific value.

The level of protection for AEI's and SSI's is classified under four levels. The 4th Level designates sites of general interest where any development, notably any quarry, must be permitted. Nature reserves naturally belong to this class.

The Plan lastly prescribes Local Plans to identify and to protect Areas of High Landscape Value.

In addition to national and local plans, **Great Britain** benefits from regional planning levels:

1) The national level of mineral planning falls under the Office of the Deputy Prime Minister (ODPM). The planning system, published in 1996, is currently being revised (British Planning and Compulsory Purchase Act., 2004). National policies ensure that major developments do not take place in National Parks, areas of outstanding natural beauty or sites of biodiversity, geological or archaeological interest, except in exceptional circumstances. Mineral developments should be demonstrated to be in the public interest before being allowed to proceed. There are 3 Minerals Policy Statements (MPS).
   a. MPS1 (Nov. 2004) sets out the Government's key policies and principles for mineral planning in Great Britain. It designates "industrial minerals" areas where mineral extraction at some future date is a priority issue when taking land-use decisions. This approach prioritizes local environmental benefits in return for recognizing a commitment for future working. MPS1's Appendixes deal with specific minerals, notably aggregates, brick clay, and building stone.
   b. MPS2 (March 2005) covers the principles to be followed in consideration of the environmental effects of mineral working. Its Appendixes notably deal with transport, blasting, dust, noise, mine waste, and the impacts on the water environment.
   c. MPS3 covers matters related to site restoration and management. This will not be prepared until the draft Directive on the Management of Waste from the Extractive Industries has completed its passage through the EU's legislative processes.

   Furthermore, Good Practice Guidance (GPG) gives advice to local planning authorities, the minerals industry, and interested parties about how the policies in MPS1 might be implemented.
2) The overall objectives set out in MPS1 are taken into account by Regional Planning Bodies (RPBs) and the Mayor of London in the preparation of Regional Spatial Strategies (RSSs, or the Spatial Development Strategy in London). RPBs have to seek and take into account advice from county councils and other authorities with strategic planning expertise in the region.
3) Then, the local authorities in charge of the preparation of local development documents are the Mineral Planning Authorities (MPAs). Outside the metropolitan areas, MPAs comprise county councils and National Park authorities. In Greater London and the metropolitan areas, MPAs are respectively, the London borough councils and the Metropolitan district councils.

MPAs must prepare a folder of documents for delivering the planning strategy for the area. They will notably include Local Development Documents (LDDs) and a Statement of Community Involvement. These documents should be in general conformity with the RSS. Local authorities must use MPSs and GPGs as guidelines.

LDDs include a core strategy, site specific allocations of land, area action plans where needed and a proposals map. They will form the statutory Development Plan together with the relevant RSS. Development plans for minerals should provide a clear guide to mineral operators and the public about the locations where mineral extraction may take place. They should set out clear and appropriate development control policies, which should include the safeguarding both of sensitive environmental features and of mineral resources with potential for future extraction. They should cover all aspects of environmental and resource protection including restoration.

The form, content and the procedures for making, altering and replacing these plans are given in the Town and Country Planning (Local Development) (Great Britain) Regulations 2004.

3.4.3 Rehabilitation and renaturation of quarries in the reviewed countries

The purpose of land renaturation is to reintegrate the pit or quarry into the environment after operations have ceased. Mineral workings can often provide the opportunity in their restoration and after-use to create new wildlife habitats, landform and sites of geological interest. *In all the five countries of this study, land renaturation/restoration is obligatory.*

Proposals for site renaturation and aftercare form an important part of the application for a quarry permit. Where there is serious doubt about whether satisfactory reclamation can be achieved at a particular site, there must also be doubt whether permission for mineral working should be given.

In terms of content, the proposal should be sufficiently detailed for a realistic overview of:

- Intended after-use of the site,
- Phasing of progressive restoration activity,
- Final landform and landscape,
- Monitoring and supervising procedures by the operator to ensure proper completion of the restoration , and
- Details of the materials to be used including overburden, soils and soil-forming materials.

Tunisia and **Malta** have climates quite similar to that of Lebanon. These two countries face difficulties in site restoration due to their relative shallow soils and limited water resources. It is therefore difficult to successfully establish vegetation, both natural and landscaped without carefully consideration and selection of vegetation, which is to be included as part of a renaturation and landscaping strategy.

In **Malta**, permit applications must include the detailed arrangements for site restoration and for aftercare which should cover a period of five (5) years (Maltese Development Planning Act, 1992; and Maltese Minerals Subject Plan, 2002). Applications must also include details of the longer-term management of sites, particularly where restoration is for agriculture, forestry, amenity, or nature conservation purposes. Where it is agreed with the MEPA that it is not appropriate to include the detailed restoration scheme, the application should however include a concept scheme including illustrative details of contouring and landscaping. Proposals for minerals development should be designed, wherever possible, to allow a phased sequence of extraction, restoration and implementation of the planned after-use. *To secure adequate renaturation, the MEPA is requiring since 1992 a restoration bond on new and extended sites.*

In all cases, on completion of restoration works, operators must demonstrate that quarry faces have been rendered stable. The restoration scheme for the site must indicate the proposals for treating quarry faces. On the cessation of extraction activities, all buildings, plants and machinery must to also be removed from the site. Any haul roads that are not integral to the after-use of the site must be removed as well. Inert wastes, wherever possible, should be recycled and used as construction materials or may be used in the restoration of existing and new quarry sites.

In **Tunisia**, an operator who wishes to cease quarrying activities should inform the administrative authority. The latter then proceeds to a site visit and evaluates the rehabilitation works with regards to the terms of the initial consent. If it is found that the operator is not in compliance, the administrative authority can complete the rehabilitation at the operator's expense. Anybody who would infringes on the rehabilitation obligation is liable to a term of imprisonment of three months to one year and a fine of 2.000 Dinars (1.250 US$) at the maximum, or to one of these two penalties. *However, there is no guarantee mechanism* (Tunisian Law No. 89-20, 1989).

In **France**, the permit defines the conditions of rehabilitation of the site at the end of operation (French code of Environment). Any quarry operator who does not comply with the requirements for rehabilitating a quarry authorized will be refused further authorization (French code of Environment).

In order to protect the public safety, easements may be instituted on old quarries to limit construction and development works and promote the establishment of camping sites or Caravan Parks. The institution of easements in the public interest is established either by request of the party applying for authorization, request of the Mayor of the commune in question, or initiative of the representative of the State in the department (French code of Environment).

The project defining the easements and the area is subjected to a public inquiry, in accordance with the measures of the French Law No 83-630 of July 12, 1983 relative to the democratization of public inquiries and the protection of the environment, and to the opinion of the Municipal Councils of the communes through which the area extends. The easements shall be appended to the zoning layout of the commune as provided for in the Article L.126-1 of the Town-Planning Code.

In **Great Britain**, MPA's have the power to impose restoration conditions as part of granting consent (British Environmental and Planning Acts, 1995 and 2004). When an MPA decides to impose restoration conditions, it has also the power to impose aftercare conditions. These latter cannot require the operator to complete steps that will take longer than five years from the date the restoration condition is satisfied. The steps included in the aftercare condition can relate only to the treatment of the land, such as draining, cultivation, planting, fertilizing and watering.

The MPA monitors the aftercare and issues a certificate once it has been completed.

Guidance on good technical practice for the reclamation of mineral development sites as well as potential site after-uses are contained in *Mineral Planning Guidance 7 – Reclamation of Mineral Workings (MPG 7)*. Moreover, the use of mineral waste in site restoration should conform to the relevant waste management controls adopted by the Environment Agency, and in due course, by the competent authority to be designated under the forthcoming EU Mine Waste Directive. It is intended that MPS3 will update MPG 7 on matters related to site restoration and management, to take into account the requirements of the EU *Mine Waste Directive*.

In **Canada** (Québec), renaturation must be completed within a time limit of one year – exceptionally two years – after the date when the operation of the pit or quarry has ceased (Canada-Quebec Regulation respecting pits and quarries, art. 45. No date is specified).

- Where the operator has chosen to restore the site simply by leveling and revegetation, the land restoration plan must be carried out concurrently with the operation of the pit or quarry.
- If the topsoil and overburden are preserved during the operation of the pit or quarry, they must be stored separately. The topsoil and overburden shall later be deposited on the leveled surface during restoration, to facilitate the growth of vegetation (Canada-Quebec Regulation respecting pits and quarries, art. 40. No date is specified).
- In the case of a pit, the restoration plan must not allow the slope of the worked surface to be more than 30º from the horizontal unless the ground is to be stabilized in some way to prevent landslides and erosion. Where a quarry is located on the side of a hill, mountain, cliff or slope, the final vertical cut must never exceed 10 meters. The operator may make several superimposed vertical cuts of at least 10 meters provided such cuts are separated

by horizontal terraces at least 4 meters in width (Canada- Quebec Regulation respecting pits and quarries, art. 38. No date is specified).

- Each horizontal terrace must be covered with vegetation.
- Where the restoration project consists in creation of an artificial body of water, it must be designed to prevent water stagnation. Such artificial body of water must be at least 2 meters in depth at its shallowest point (Canada-Quebec Regulation respecting pits and quarries, art. 42. No date is specified).
- On completion of the land restoration project, the surface of the pit or quarry must be free of all debris, rubbish, stumps, non-usable material, pieces of machinery or other such litter.

The Quebec regulation also provides that the operator of a pit or quarry may restore the site by establishing a landfill in the pit or quarry. In other words, waste management facilities are not differentiated from the rest of the site. The application for authorization to establish such a landfill must be filed with the Minister not less than 1 year before total or partial cessation of the operation of the pit or quarry. In addition, the land filling must begin at the latest 1 year after the pit or quarry operations have ceased. If granted, the authorization operates as an amendment to the restoration plan (Canada-Quebec Regulation respecting pits and quarries, art. 47. No date is specified).

Most countries of this study recognized that minerals extraction may proceed over several decades, during which the needs and aspirations of the public could substantially change. With regards to rehabilitation, this may impact the appropriate after-use of the site. As standards change, it may be necessary to review consents with a view to imposing new conditions. In most countries, the regulatory authority may compel quarry operators to comply with newly established laws and standards, even if they were already in operation prior to the ratification of the law.

- In **Malta**, the Malta Resources Authority, which now manages the Police Licensing System, requires an annual review of licenses. This leaves room to impose new conditions and standards on the operator for rehabilitation.
- In **France**, the DRIRE can require a revision of the permit provisions whenever it deems necessary.
- In Canada (Québec), the operator may, at any time, alter the submitted restoration plan by forwarding the modified plan to the Minister for approval similar to the original restoration plan.

3.4.4 Financial issues of quarry planning, rehabilitation and renaturation

3.4.4.1 Fees and Taxation of quarry management

In **Great Britain**, fees and charges are defined by the Secretary of State but are to be paid to the Local Authority.

The Secretary of State publishes and regularly revises a scheme prescribing:

1. Fees for quarry permit application by local authority permits;
2. Fees for the variation, transfer and surrender of permits; and
3. Charges for the subsistence (renewal) of permits.

Moreover, the financing scheme:

- Makes different provision for different cases, including different provision in relation to different persons, circumstances or localities;
- Allows for reduced fees or charges to be payable in respect of permits granted to the same person;
- Provides for the times at which and the manner in which the payments required by the scheme are to be made.

In the financing scheme, the Secretary of State also, secure that the fees and charges payable under the scheme are sufficient to the extent practicable, taking one year with another, to cover the expenditure incurred by:

- Local authority regulators in exercising their functions in relation to local authority permits
- The Environment Agency in exercising its functions of control of the respect of the authorization conditions, or in preparing guidance in relation to the authorization of installations and plants covered by local authority permits. The sums paid to a local authority regulator related to the expenditure incurred by the Environment Agency shall be paid by the local authority regulator to the Environment Agency.

In **France**, the Classified Installations Law established a non-recurring tax payable by all classified installations at the time of any authorization or declaration. It established furthermore an annual charge payable by those among the said establishments which, by virtue of the nature or volume of their activities, involve special risks for the environment and which, for that reason, require detailed regular inspection.

3.4.4.2 Rehabilitation and renaturation funding and guarantees

Quarries activities may proceed over a long period and may even cease temporarily only to reactivate at a later date. As extraction may cease either in the short or longer term, it is difficult to establish whether the activity may restart or if the quarry has been abandoned. As a result, restoration guarantees are used in many countries to protect against restoration failure. It acts as a safeguard for regulatory authorities and the public to ensure that restoration will take place to an acceptable standard and to protect against a number of factors including:

1. Liquidation or bankruptcy of the operator
2. Inadequate monitoring and enforcement
3. Operator "walking away" from obligations
4. Inadequate or inappropriate conditions on consents
5. Shortage of fill materials

A financial guarantee is typically used to ensure sufficient resources are set aside to cover the expenditure of restoration. Commonly, guarantees are required for the following:

- to ensure that restoration occurs
- to ensure landscaping schemes are carried out
- to ensure the removal of plant and machinery on the completion of extraction

Moreover, these guarantees can come in several forms including:

- Bonds
- Deposits
- Mutual Funding Schemes operated through trade or similar umbrella associations.

In devising mechanisms to act as a guarantee, it is important that excessive costs are not placed on operators in the short-term, which could reduce investment in other environmental mitigation measures or investment in modern plant and equipment.

Two types of guarantee can be identified:

- A guarantee is determined on an ad hoc basis according to the type of mineral extracted and extent of the consent
- A nationally organized funding scheme organized for example through a trade association, as in the UK, which is targeted at restoration failure arising from liquidation or bankruptcy.

In some countries, guarantees are underpinned by legislation, while in others they are common practice, required through conditions or agreements.

Guarantees or financial sureties are a form of risk management and risk is normally defined in engineering terms as "Hazard" times "Probability of Occurrence". In this case, the hazard is an abandoned quarry site requiring action. The probability of this occurring is determined by many factors. These include:

- *Poor Physical Planning for Closure* - It is obvious that, if a quarry is not designed with its eventual closure being taken into account, there are likely to be problems.
- *Insufficient money* - An excellent plan is not useful if there are no funds to implement it. This problem can arise for a number of reasons, including:
  - Cash flow problems, caused for instance by low prices of aggregates.
  - Premature closure, which can arise for many reasons,
  - Company failure, which is a concern because quarries are often run as single operation companies and cannot rely on their parents, which may, in any case, not have any other income.

Sureties mitigate risk but do not eliminate it. Examples of remaining risks include:

- Financial failure of the provider of the surety
- Legal risks: it is only when a surety needs to be realized that its effectiveness is really tested.

The most secure approach to guaranteeing closure funds would be to require a full up-front deposit of cash. However, in deciding on amounts and methods of providing securities, "*regulatory agencies have recognized the need to balance the cost of reducing risk against the benefits this may achieve, and do not normally insist on such a deposit. This is because they recognize that it would impose unnecessarily high costs, when the risk of closure in the first few years of operation is normally very low*" **(**Proceedings of a seminar on financial guarantees and securities in the extractive industry located on: www.odpm.gov.uk).

There are several benefits to financial guarantees. First and foremost they provide a level of certainty for communities and regulators that financial failure will not lead to long standing environmental costs or public sector costs. Secondly, they assure the Polluter Pays Principle. Third they assure industry against reputational risks and provide incentives for progressive restoration. Lastly, they provide an incentive for the dissemination of good management practice (ODMP, UK 2006).

The costs of guarantees on the other hand take the form mainly of opportunity costs, where there would be displacement of investment capital, especially in the case of "up-front" or cash deposit schemes.

The **English/British** experience is particularly interesting. Companies involved in quarrying activities decided to create mutual restoration funds. If it appears to the MPA that a bond or

guarantee is required but an operator can demonstrate that it is covered by an industry guarantee scheme, the Government considers that a bond should not be necessary.

First, it was the Sand and Gravel Association, known as SAGA - that inaugurated a sand and gravel restoration guarantee fund in late 1974. The fund was underwritten by SAGA's members as a mutual fund, which would give minerals planning authorities the confidence that any site in the ownership of one of the members would be restored to an acceptable standard in the event of that member's insolvency.

In 1997, SAGA and the British Aggregate Construction Materials Industry (BACMI) - the other trade association at that time dealing generally with those members producing crushed rock, lime and asphalt, together with about 60% of concrete and sand and gravel production - merged to form the Quarry Products Association (QPA).

Meanwhile, the Chancellor announced that he was considering if there was justification for introducing specific environmental taxation of surface minerals extraction (including quarry products). In July 1999, the QPA submitted to the Deputy Prime Minister a detailed package of voluntary and regulatory initiatives to form a realistic alternative to the proposed aggregates tax. The QPA's 'New Deal' package included a proposal for the setting up, management and operation of a *Quarrying Industry Sustainability Foundation*.

While it was recognized at the start of QPA that the fund was only applicable to sand and gravel, it was agreed that crushed rock would need to be included as soon as possible, in order to be able to claim coverage for all the aggregate sites in members' ownership.

Key elements of the QPA's package included:

- Creation of a *National Foundation for Environmental Improvement and Sustainable Development*. The Foundation, wholly funded by the industry and estimated to cost £25 million per annum, would have directed key initiatives including:
    - Rehabilitation of orphan quarries
    - National research programme on the sustainable development of quarrying
    - Funding and development support of the Aggregate Advisory Service
    - Extended Quarry Restoration Guarantee Scheme
    - Biodiversity Plan
- Introduction of a compulsory *Transport Code of Practice* developed through partnership with local authorities and other interested parties.
- Industry wide implementation of ISO 14001 (Environmental Management Systems).
- Environmental Assessments for ALL new mineral extractive developments, regardless of size.

- Revision of the Planning Fee Structure, with higher fees to local authorities to enable a greater emphasis on consistent monitoring and enforcement of the terms of consents. It is proposed that these fees would be discounted for companies which have implemented ISO 14001 in order to encourage the extension of best practice in environmental management across the whole of the industry.

Today, the QPA is the major trade body representing UK companies involved in aggregates, silica sand, lime, asphalt, ready-mixed concrete and mortar production. In terms of volume, these companies are responsible for about 90% of UK output. The QPA fund covers some 800 sites. QPA has some money in the bank, attracting as high an interest rate as can be achieved, which is available at very short notice for any claim. Members have also committed themselves to support claims up to a total of £1 million and any one claim of £500,000. Their obligations are pro-rata on their production volumes.

In parallel, in late 1999, the British Aggregates Association (BAA) was founded representing mostly smaller operators, the 10 % left. The new association had been initiating its own scheme, based on similar lines to the old SAGA scheme.

The SAGA and QPA funds have never, in their combined life of some 32 years, been called upon. Progressive restoration is now very much good practice, either because it is demanded by the MPAs as part of the planning consent, or because the operator sees it as more efficient, effective and less risky than leaving it until the very end of the quarry's operational life. This, in turn reduces the likelihood of a member's financial difficulties causing catastrophic restoration default.

However, some research showed that the low cost of the primary aggregates in the UK had led the industry to decrease the efficiency with which aggregates were used. A research suggested that materials wastage on building sites in the UK was equivalent to building 13,000 extra homes every year.

In 2002, the British Chancellor of the Exchequer finally introduced a new tax, the Aggregates Levy in order principally to secure the system, and to provide an incentive to increase the recycling of aggregate materials, the re-use of components and materials and the utilization of secondary aggregates where appropriate. The tax aims over time to reduce land take by quarrying and the environmental impacts associated with it.

The new tax supplies an *Aggregates Levy Sustainability Fund* that can operate an integrated package of policy measures aimed at developing a sustainable aggregate supply industry including planning measures, regulations, product standards, research programs, promoting the uptake of environmental management systems and targeted information programs. However, the QPA's fund has become a valuable complement to the tax, especially concerning the issue of orphaned quarries.

In **France**, the proof of the applicant's technical and financial capacities to rehabilitate the site after closure consists in a provision of financial guarantees. They are provided by a written commitment from a credit institution, or an insurance company (French Decree No. 77-1133, art. 23-3, 1977). Its amount depends on the category of installation and its dimension.

This demand is required for all Classified Installations but it binds the grant of authorization only for a few categories of installations, two of whom are waste storage installations and quarries (French Decree No. 77-1133, art. 23-2, 1977), and it is required after the original authorization as well as after authorization for a change of operator. Activity at such facilities cannot start unless financial guarantees have been provided. The authorizing Order sets the amount of the financial guarantees required and the conditions in which this amount has to be updated.

In **Canada**/**Québec**

In Canada, several funding approaches towards rehabilitation are undertaken, following certain criteria and principles in order to decide who shall pay and how for quarry creation.

These principles and criteria are used in Canada to assess funding approaches to abandoned mine (or quarry) rehabilitation. These principles and criteria are adopted from Castrilli 2003 (Castrilli et al., 2003) (Table 12).

Table 12 Principles and criteria to assess funding approaches (Castrilli*, et al,* 2003)

	Principles and Criteria	Description
1	Polluter pays	The one in responsibility for the quarry should finance rehabilitation costs
2	Beneficiary pays	The ones who benefited from the quarry (e.g. public) should finance rehabilitation costs
3	Fairness	Fairness refers to notions of certainty of process, effectiveness, efficiency, clarity, consistency, and timeliness in achieving environmental objectives. It is related to Polluter and beneficiary pays principles.
4	Sustainable development (SD) goals	SD should provide the overall framework in which a quarry rehabilitation program should be developed.
5	Openness, accessibility, participation	Public input and access to information about the quarry rehabilitation needs to be always taken into account.
6	Revenue generating capacity	The funding mechanism needs to generate sufficient funds for the task at hand.
7	Administrative ease	The generation of revenue, its collection and application needs to be through a relatively simply process.
8	Economic impacts	The economic impacts of the funding approach undertaken needs to be assessed in order to safeguard the competitiveness of the industry among other things.
10	Discourage future site abandonment	The funding approach should also discourage future abandonment of quarries without rehabilitation.
11	Public perception	The perception of the public towards the funding approach is important, as it also impact political initiatives towards rehabilitation.

Five funding approaches are undertaken in Canada (Castrilli, Joseph F. & C.N Watson and Associates Ltd., 2003):

- Government funded programs from general revenues;
- National-municipal government funded cost-sharing arrangements from general revenues;
- Levies on industrial production;
- Government- industry partnerships; and
- Non-profit organization trust funds.

First, the Canadian government or governmental bodies (whether national, provincial, municipal or a combination of national-provincial- municipal) could pay for the rehabilitation of abandoned quarries out of general revenue. The government either did not require, or did not enforce, adequate rehabilitation during the operating life of the quarries and there is now

no one available (or some other reason) upon whom to impose these financial obligations. This approach makes all taxpayers responsible for financial resolution of the problem (Castrilli, et al. 2003).

Second, the present Canadian quarrying industry could contribute to a fund that can pay for rehabilitation of orphaned/abandoned quarries. The theory behind this funding approach is a generalized notion of polluter pays or internalization of external costs imposed on the industry as a whole as a cost of doing business in the jurisdiction in the future. This approach makes the quarrying industry, and consumers of the products made by the industry, responsible for the financial resolution of the problem (Castrilli, et al. 2003).

An important example to illustrate here is that of Ontario and its 'Aggregate Resource Act' (ARA). Administered by the Ontario Ministry of Natural Resources, the purposes of the ARA is to rehabilitate land from which aggregates have been acquired. To assist in this initiative, the ARA recommended the establishment of the 'Aggregates Resources Trust' that provides for the 'rehabilitation of abandoned pits and quarries, including surveys and studies respecting their location and condition and research on aggregate resource management, including rehabilitation' (Castrilli, et al. 2003). 'Rehabilitation' herein is defined as restoring the land to its former use or condition or changing it into something compatible with the use of adjacent land. Regulations within the ARA impose an annual six-cent per ton licensing fee for each ton of aggregates removed from the site during the previous year. One-twelfth (or 0.5 cents) of the six cents per ton fee must be provided to the Trust for purposes of abandoned pits and quarries rehabilitation and research (the other 5.5 cents go to the municipal, county or county governments in which the site is located). Within the Trust, a separate Management of Abandoned Aggregate Properties Program (MAAP) specifically targets the quarries abandoned prior to the start of 1990. Over 200 hectares have been rehabilitated from 1990-2001, costing $2.5 million dollars (TORAC-Ontario- Canada).

Third, the Canadian government could provide incentives for existing quarrying companies to rehabilitate orphaned/abandoned quarries (government-industry partnership). These incentives could come in the form of tax deductions, exemptions from liability, issuance of a quarrying license on an adjacent site, financial contribution by government in partnership with a quarrying company, or other similar arrangements. This approach makes both taxpayers and consumers responsible for financial resolution of the problem (Castrilli, Joseph F. & C.N Watson and Associates Ltd., 2003). In Ontario, the Ministry of Northern Development and Mines (ONDM) and the Ontario Mining Association (OMA) recently signed a memorandum of understanding that would allow mining companies to make voluntary contributions to rehabilitate abandoned mine sites in return for a tax deduction and indemnification from liability. The ONDM would administer funds received from industry, government, or other parties.

Fourth, the Canadian government could, without imposing new taxes or fees on the quarrying industry, (1) re-direct a portion of existing quarrying tax revenue, and (2) reduce existing incentives to the industry and earmark both streams to orphaned/abandoned quarry rehabilitation generally, or through a fund specifically designed for this purpose. This approach makes both taxpayers and consumers of mineral products responsible for financial resolution of the problem (Castrilli, et al., 2003).

Fifth, the Canadian government could use a combination of the above or related funding approaches, including contributions from non-governmental organizations (e.g. large companies) or other such means. The latter (Trust fund) approach blends indeterminate levels of industry, public (and individual) financial contributions to attempt to solve the orphaned/abandoned quarry problem on a programmatic basis. Companies, governments, individuals contribute money without having any particular site in mind when they make their contribution. In that regard, the approach works like an industry levy contributed to a fund with the difference that the industry and private contributions are voluntary, and come with tax deductions (Castrilli, et al., 2003).

For future permitting of mines in Canada, Québec for example (in the case of a pit) demands a guarantee of 5,000 $ where the stripping is less than or equal to 1 hectare and 4,000 $ per hectare or fraction thereof where the stripping is greater than 1 hectare, that guarantee being in one of the following forms:

- Cash or a certified check made out to the Minister of Finance;
- Bearer bonds, cashable at all times, issued or guaranteed by the Government of Québec, the Government of Canada or a municipality and whose market value is at least equal to the amount of the guarantee required;
- A joint and several deed in the form of security or of an insurance policy, with a waiver of the benefits of discussion and division, issued by a banking institution, a savings and credit union or an insurer;
- An irrevocable letter of credit issued by a banking institution or a savings and credit union.

The *Minister* may use the guarantee where the operator neglects or refuses to carry out his restoration plan or where the operator becomes bankrupt or, if the operator is a corporation, if it winds up its affairs. Before using the guarantee, the Minister must give the operator 60 days advance notice. Upon expiry of that time limit, the Minister may use the guarantee for restoration of the pit unless the operator has, in the meantime, undertaken the implementation of the restoration plan.

Where the operator does not complete the restoration plan, the Minister may give another 60 days advance notice and use the guarantee.

Where the operator chooses a restoration method consisting in levelling and renaturation with appropriate vegetation of the site or in a landfill made up of earth, sand or stone, followed by surface renaturation, 75 % of the guarantee shall be remitted to him after the Minister has ascertained that he has complied with the rehabilitation scheme. The balance of the guarantee is remitted after two years, when the renaturation of the land is completed, unless the environmental milieu will not support perennial vegetation.

Where the operator chooses other restoration options, the guarantee shall be remitted to him in its entirety after the Minister has ascertained that the operator has complied with the rehabilitation scheme, insofar as these apply to the restoration plan which has been carried out. The guarantee shall not be remitted to the operator if it has been used by the Minister. However, if the amount of the guarantee is greater than the cost of the restoration work carried out on the Minister's orders, the balance shall be remitted to the operator.

In **Malta**, the only considerable mineral that is quarried and used for construction purposes is limestone, and in specific globigerina limestone (for construction of domestic and commercial buildings) and crystalline limestone (turned to sand and gravel to be used in concrete slurries).

The existing policy and regulatory framework for quarrying and mining present in Malta (Malta Environment and Planning Authority, 2003) is guided by several policies, namely:

- International Policy
- Existing Structure Plan Policy
- Local Plan Policy
- Development Control System

On the international level, not only has Malta voluntarily bound itself to the Rio Declaration on Environment and Development in 1992 (specifically the concept of sustainable development), yet is legally bound by the regulation set forth by the European Union, specifically concerning the objectives first set by the Single European Act (Article 130) (Malta Environment and Planning Authority, 2003):

- To preserve, protect and improve the quality of the environment
- To contribute towards protecting human health
- To ensure a prudent and rational utilization of natural resources

In 1990, Malta had a Structure Plan that sought to meet the main objective of satisfying demand for aggregates by fully exploiting existing quarries. However within this plan, controls on both the siting of the quarries and on the operation and restoration of quarries were discussed and eventually carried forth into the Local Plan Policy (Malta Environment and Planning Authority, 2003).

The Local Plan Policy is a set of seven local plans for seven areas to expand upon adopted policies in the Structure Plan in order to give more practical guidance where necessary (e.g. identifying future quarry areas).

With respect to quarrying, the Development Control system in Malta first organized the quarrying sector by the issuance of a (1) Code of Police Laws, (2) Development Planning Act, and (3) Environment Protection Acts.

The oldest of the three was the Code of Police Laws, in which the quarry applicant was required to submit details of land ownership, a site plan, and a declaration saying no quarrying would take place until the issuance of a license. In return the police consulted several public authorities (Planning Area Permits Board, the Director of Trade, The Department of Environment, the Director of Works -Quarries and Explosive, the Ministry of Tourism, the Director of Museums, the Water Works Department and the Chief Government Medical Officer among a few others) that have a right to refuse to grant clearance, or subject clearance to certain conditions. However, no restoration schemes were identified and no conditions in reality were imposed. Furthermore, the renewal of a license happened more or less automatically without really any monitoring and controls ((Malta Environment and Planning Authority, 2003).

The Development Planning Act established the Malta Environment and Planning Authority (MEPA) and replaced the license regime with development permission (permits) requirements. The Act also established a new development control system through the requirement of Environmental Impact Assessments for most quarry developments, tying landscaping and restoration requirements for quarries to bank guarantees, and requiring that MEPA permits for development to be site and area specific (in place of being tied to a specific owner) (Malta Environment and Planning Authority, 2003).

Lastly, the Environment Protection Act establishes a number of key principles, including the protection of the environment through preventative and remedial measures, the consideration of environmental as well as socioeconomic concerns, the minimization of pollution, the safeguarding of biological diversity and cultural heritage and the conservation of natural resources (Malta Environment and Planning Authority, 2003).

Present and Future Quarries in Malta

MEPA requires a restoration bond on new and extended sites in Malta. Restoration guarantee mechanisms are in place to ensure against (1) the liquidation of the operator, (2) inadequate monitoring and enforcement, (3) operators walking out from obligations, (4) inadequate conditions on consent and (5) shortage of fill material (Malta Environment and Planning Authority, 2003).

MEPA has identified two types of guarantees, the first of which is a guarantee that *"is determined on an ad hoc basis according to the type of mineral extracted and extent of the consent, either by reserve, production or consented area*" (Malta Environment and Planning Authority, 2003), and the second is a nationally organized funding scheme (e.g. organized through a trade association). The second scheme however is not implemented in Malta due to the absence of such a trade association (Malta Environment and Planning Authority, 2003).

On the Maltese Islands, it is now standard practice for new applicants for minerals and minerals related development to require bonds to be submitted to ensure that certain works are carried out. A bond of amount X is initially submitted but is reduced by a certain percentage once landscaping strategy is agreed. The bond would continue to be reduced on a sliding scale once certain works are carried out.

Abandoned Mines in Malta

Due to the fact that quarrying in Malta used to require only a license under the Code of Police Laws (see Section.3.6.2), whereupon no restoration scheme was required, the rehabilitation of abandoned quarries places no legal requirements to past quarry operators.

To deal with the issue of abandoned quarries in Malta, the government is simply contracting out rehabilitation of abandoned quarries to the private sector, taking into account that the private sector is to charge a per ton tax (3.26 € per ton in 2005) on uncontaminated construction material (between 2003 and 2005, 3.57 million tons of construction material have been disposed in the various quarries in Malta). In this case, the private sector achieves cost recovery from the tipping fees of disposing of construction wastes (WasteServ Malta Ltd. Website). The contractors in Malta who wish to dispose of construction wastes at quarries, are to register with the private company(ies) selected by the government to rehabilitate quarries.

3.5 Impacts and influences of quarries on the environment and possibilities for their mitigation

In Lebanon several types of impacts from quarrying activities are identified at different level of significance. These impacts include among others all the positive and negative, short and long term, direct and indirect, reversible and irreversible impacts on the physical, biological and socio-economic environment. On the other hand there are possibilities for mitigation of the environmental pollutions and disturbances. This is very important, because principally before the initiation of each quarry should be exist a mitigation plan. This plan should address all measures, whether technical, legal, social, and economical or other should be considered in order to prevent, reduce or mitigate the negative impacts of the proposed quarry. In this mitigation plan and for each impact, all the possible mitigation measures should be outlined and the preferred one described in details, including the reasons for choosing it (World Bank, 1991; El-Fadel M*., et al*., 2000). The potential environmental impacts of the preferred mitigation measure should also be discussed.

In this chapter will show following the literature studied, what are the most important impacts of quarries on the environment and what for possibilities there are to mitigate them.

3.5.1 Quarries and physical environment

3.5.1.1 Impacts on water resources

Impacts to ground and surface water include:

- Decreasing aquifer recharge and increasing surface water runoff where topsoil is removed leaving bare rock surfaces
- Disturbing land drainage, and overloading and eroding receiving watercourses, due to greater and faster runoff and uncontrolled pumped discharge of surface water and groundwater
- Altering the surface over which water flows
- Changing the pattern of surface water flows
- Changing the surface and groundwater resources quantity and quality, such as partial blockage of streams due to roads or crushers construction over or within the right of way of streams and water contamination by particulate matter or by waste material deposited on river banks
- Increasing the risk of contamination to underlying aquifers due to removal of the natural filter medium
- Exposing groundwater to quarry wastes

Mitigation measures:

- Avoiding of places with water springs and bourns;
- Replacement of water flows;
- Fast renaturation in order to improve the water household.

3.5.1.2 Impacts on air pollution

The main **impact** on air pollution is the increase in dust emission. Dust is any solid matter, emanating from a surface mineral working or from vehicles serving it, which is borne by the air. It can be emitted from a stack as a plume or it can be picked up by the wind from the ground, the surface of a road or a stockpile. Depending on their chemical composition, the particles can be chemically active. The main effects of dust are:

- Reduction in visibility due to dust plumes
- Coating and soiling of surfaces leading to annoyance and loss of amenity
- Physical and/ or chemical contamination and corrosion
- Increase in the concentration of suspended particles in runoff water
- Coating of vegetation and contamination of soils leading to reduced photosynthesis; inhibition of growth, destroying of leaf tissues, premature leaf fall, degradation to tree bark due to alkaline dust and possibly reduced value of agricultural products
- Increase in health hazards due to inhalation of dust, e.g. asthma, or irritation of the eyes
- Obstruction of road signs
- Deterioration of the quality of life

Mitigation measures include:

- Planting wind breaks
- Covering crushers, screens and heaps of stared material
- Misting access roads and any other place where dust is likely to deposit and accumulate
- Adequately covering trucks; the cover should fold on the vertical sides at least 50 cm and be tightly roped to prohibit dusting or dropping of gravel
- Fitting dust creating equipment with effective dust suppression systems

3.5.1.3 Noise related impacts

Quarry noise is normally associated with vehicles, trucks, lorries, caterpillars, operation of draglines, dredges, dampers, drills, pumps and crushing plant, construction of screening bunds, earth moving and the stocking of overburden mounds and blasting. Noise effects include:

- Annoyance to the neighbourhood and deterioration of the quality of life
- Disturbance to animals and birds leading to their poor production and breeding success levels

Mitigation of noise appropriate measures includes:

- Providing noise control measures
- Limiting the hours of operation and avoid working at night

3.5.1.4 Impacts due to vibration

Vibration, due to blasting, is transmitted through the ground and air pressure waves. It can have the following effects:

- Shaking of buildings and people which cause damage and nuisance
- Propelling of rocks fragments in the air due to explosion which is dangerous to people and property both inside and outside the site
- Slight disturbance to the deep subsurface structure that may lead to modifications in water courses

Mitigation of vibration appropriate measures includes:

- Testing suitable blasting techniques adaptable to each specific site
- Measuring ground vibration and air overpressure transmission as a function of distance and charge of a delay
- Monitoring and re-optimizing throughout operation and whenever required by the authority
- Adopting adequate blasting design, accurate setting and drilling, and correct charging and explosives
- Using more frequent blasting, reducing the surface area and the degree of surface heave
- Using delay (successive) detonation, which is preferable to instantaneous firing since it gives better fragmentation, higher efficiency of explosive used, reduced vibration and has better control of the rock
- Avoiding gas venting by accurate drilling and complete filling of borehole
- Blasting a limited heave depth not exceeding 6 meters and adopting terracing method since it reduces fly rock risks, vibration, overpressure and the probability of unstable quarry faces and improves work efficiency
- Covering blasted surface, particularly in populated areas and when distance to roads is less than 200 m
- Avoiding blasting early in the morning, in the evening, on weekends and in public holidays
- Avoiding blasting in adverse weather conditions; i.e. when moderate to strong winds are towards the sensitive areas or during cloudy days with a low cloud ceiling, foggy or hazy

days as a heavy cloud cover at warm air temperature at high altitudes reflects noise back to the ground

3.5.1.5 Impacts on landscape

Landscape changes and visual intrusion can result from quarrying activities. Landscapes are affected by:

- Changes in land values
- Quarrying activities and shape
- Colours contrast
- Deforestation
- Waste dumps
- Product stockpiles
- Crushing or washing plants
- Haul roads
- Soil erosion
- Effects of displacing agricultural activities
- Effects of displacing or harming cultural and archeological properties and sites of religious significance

Mitigation of landscape changes and visual intrusion appropriate measures include:

- Tree planting at a maximum spacing of 7 meters with a minimum height of 1.5 meters at planting date. These trees would only give a local treatment and could act as windbreaks. Adequate trees should be selected to meet the objectives
- Placing the crusher and other treatment systems inside the quarry site and not on the road;
- Avoiding a straight uninterrupted vision from the road to the working site
- Constructing an embankment of 1.5 to 2.0 m high to delineate the quarry site and 0.5 to 1.0 m off the right of way of rivers, valley and roads; this embankment would protect the rivers, valleys and roads and would provide local landscape treatment. It shall be protected from erosion and planted with shrubs or creepers
- Filling depressions with soil to promote vegetative growth
- Promoting vegetative growth on most quarry faces, except the vertical hard rock ones. Various practical measures can be adopted using wire mesh, geo textile, hollow mesh mats and compost material

3.5.2 Impacts on the biological environment

- Potential **impacts** on fauna and flora: either directly through removal by clearing; or indirectly by dust emissions, noise, water pollution and increase in the number of people
- Risk of loss of a habitat and changes likely to occur in existing habitats
- Removal of feeding areas
- Displacement of fauna

Mitigation measures include:

- Preventive measures should be applied such as screening and investigation, during the project planning, for the presence of sensitive, rare, threatened or endangered species and trying to avoid locating the project in such locations
- Since the sources of impacts are directly related to the physical environment (vibration, dust, landscape…), applying the mitigation measures of the physical environment would attenuate the biological impacts.

3.5.3 Impacts on the Socio-Economic Environment

3.5.3.1 Social impacts

Potential impacts of the quarrying activities on the workers' and nearby residents' health and safety, that may result from:

- operation of equipment
- circulation of hauling vehicles
- use of explosives
- propelling of rock fragments
- vibration
- difficulties in accessing the quarry site
- Increase in mosquitoes due to the collection of rain in the quarry depression which creates a good environment for mosquitoes
- Effects of relocating nearby settlements, if any

3.5.3.2 Impacts related to the transport sector

- Increases in the number and size of vehicles on road causing congestion, accidents and difficulties for pedestrians
- Damage to road and their verges, which are not designed to carry the weight of the vehicles used to carry quarrying products or equipment
- Spillage or drop of material onto road spread of dust and formation of mud

- Creation of visual intrusion, air pollution, dust, noise and vibration in areas adjacent to the roads

Transport related impacts can be minimized by applying the following **mitigation** measures:

- Strict respect of permissible load capacity of trucks
- Regular maintenance of trucks
- Adequate site entrance
- Sign posts at and ahead of quarry sites for at least 200m
- Limiting hours of work
- Proper truck sheeting
- Provision of vehicle washing facilities at site, where mud is a potential problem
- Release of information and instruction leaflets to drivers:

3.5.3.3 Economic Impacts

- Employment opportunities generated during quarrying activities
- Changes in the economic status of the region where the quarrying works are supposed to take place.

Mitigation measures:

- Some impacts, such as relocation of people, should be prevented by choosing a location that would not require any resettlement. Any relocation activity, when inevitable, should be accompanied with compensation
- Moreover, training programs should be undertaken for staff and laborers to ensure proper management and avoid accidents, thus preventing harm to their health and safety.

3.6 Rehabilitation of quarries – scenarios and strategies

3.6.1 Definitions terminologies: Rehabilitation, Restoration and Reclamation

Several expressions are used in reference to efforts for improvement and recovery of degraded sites, such as mines and quarries; the most common of which are: **rehabilitation**, **restoration** and **reclamation**. Each of these terms has a distinct meaning from a technical and environmental standpoint. Moreover, the exact meaning of these expressions varies greatly across different countries.

'**Rehabilitation'** holds a strong recuperative meaning of site reinstatement to an enhanced ecological capacity and environmental condition. This term often embeds the sense of sustainability of the site condition. '**Restoration'** embodies the meaning of returning the site or ecosystem to the greatest extent possible to its original condition. In cases where

rehabilitation involves returning the site to its original status, rehabilitation coincides with restoration (Newton G.A. and Claassen V.P., 2003). According to the state of California, '**reclamation'** entails the return of a site, usually unsuitable for any use, to an acceptable condition for a specific, and possibly temporary, use such as cultivation.

On the other hand, in the United Kingdom, as can be demonstrated in Scotland's Planning Advice Notice 64 for the Reclamation of Surface Mine Workings, the definitions of these terms vary greatly.

1) The term **'restoration'** is used to refer to "operations carried out after the extraction of material is complete and involves using subsoil, topsoil or soil-forming material to restore the site" (SEDDPS, 2002).
2) The term **'aftercare'** refers to *"steps taken after restoration to bring land up to the required standard for the intended after use"*. Thus, **after-use** can include activities such as planting, plant maintenance, fertilization, cultivation, stone picking, irrigation and drainage works.
3) **'Reclamation'** refers to the operations that are aim at returning a mineral extraction site *"to an acceptable environmental condition, and to a condition suitable for the intended after use"* **(**SEDDPS, 2002). Therefore, when compared with the definitions of restoration and aftercare, reclamation includes both processes as well as "events which take place before and during mineral extraction, for example the correct stripping, storage and reinstatement of soils" **(**SEDDPS, 2002).

Quarry rehabilitation means (Personal communication, Training on the Best Practices on Quarry Rehabilitation-Switzerland, 2006): "*To restore the land affected by raw materials extraction and related operations to a satisfactory state, with particular consideration of future land use, soil quality, biodiversity, landscape, and appropriate beneficial use*".

Rehabilitation is used as an overall term for renaturation, reclamation, restoration, or recultivation. More specifically, Ecological Rehabilitation with its wider application is more likely preferred to be used in this context (Aronson *et al.,* 1995).

For the purpose of this section, rehabilitation shall refer to the measures and actions used to reinstate land disturbed by quarrying and excavation activities to an enhanced and sustainable ecological capacity.

Rehabilitation priorities

- to minimize the impact of our operation on land, ecosystem and people
- to reintegrate the exhausted part of quarries into the landscape (as well as dumps and facilities)
- to ensured well planned land use after quarry closure, considering the needs of stakeholders
- to re-establish or preserve a functional ecosystem with sufficient biodiversity

3.6.2 Objectives of Rehabilitation

The United Nations Environment Program (UNEP) has published several objectives for the closure and rehabilitation of mines and quarries. Oberholzer and Harrison (2003) summarize them as follows:

- improving public health and safety
- increasing site physical and chemical stability
- improving site sustainability
- minimizing adverse social impacts
- maximizing socio-economic gains

For the sake of brevity, this chapter has categorized the objectives of rehabilitation into three main categories: safety, socio-economic and environmental.

Safety Objectives

The rehabilitation of damaged ecosystems such as quarried lands may aim at ensuring public safety by improving site stability, preventing accidents and injuries, in addition to the deterrence of landslides, mudslides, and rock fall.

Socio-Economic Objectives

Social objectives include appeasing public fears and concerns, and diminishing public opposition to quarrying practices. An improvement of public opinion of the quarrying industry would bring major benefits to future quarrying activities and projects. From an economic standpoint, raising the value of estate near quarry sites after rehabilitation is an important objective, often resulting in improving livelihoods and income as well in tourist and commercial areas.

Environmental Objectives

There are numerous environmental benefits associated with quarry rehabilitation, such as the recuperation of ecological conditions, restoration of green spaces and vegetation, and decrease in soil losses and erosion. Figure 9 describes the correlation that joins the rehabilitation process and the three main pillars of sustainable development.

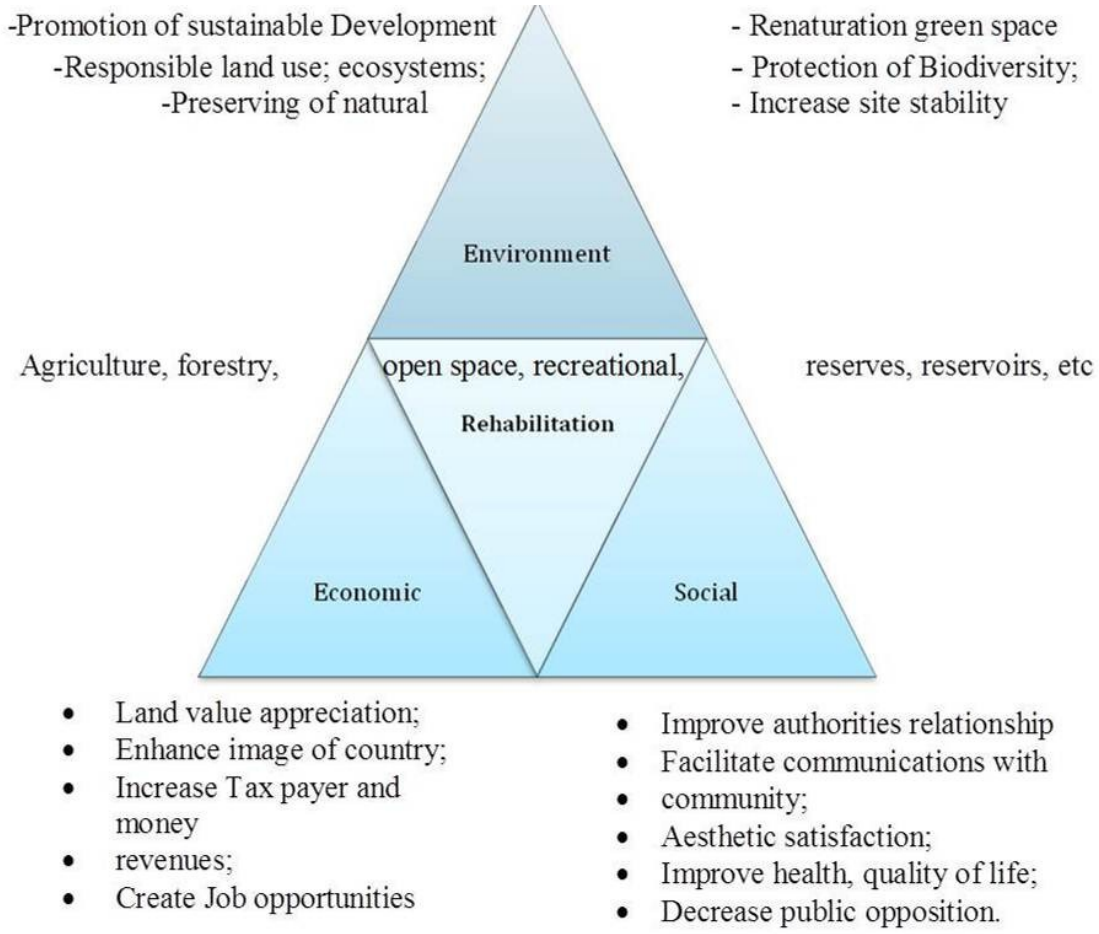


Figure 9 Rehabilitation and the three base process of sustainable development (Training on best practices on quarry rehabilitation, Switzerland, 2006)

3.6.3 Principles of Rehabilitation

There are many principles that must be taken into consideration or adopted to ensure the successful rehabilitation of a quarry site and its proper closure. The Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australian in year 2000 claim that successful rehabilitation is guaranteed by accomplishing the following:

- All stakeholders interests are considered.
- Rehabilitation and closure occur in an orderly, cost-effective and timely manner.
- Rehabilitation and aftercare costs are adequately forecasted.
- There is clear accountability of all stakeholders in their rehabilitation responsibilities (planning, regulating, monitoring, operating, aftercare, etc).
- A set of indicators are established to evaluate the completion of rehabilitation.
- A landform with similar capability to that of the site prior to extraction is achieved, unless other beneficial land uses are pre-determined and approved.

3.6.4 Rehabilitation methods

The method for quarry rehabilitation or restoration depends on several factors, among which is the selected after-use of the quarry site. In general, rehabilitation can be either rehabilitation with backfill, or low level (partial) rehabilitation.

In most cases, governments encourage rehabilitation to achieve to the highest extent possible a land contour similar to that of origin. For example, the United States government has set performance standards for the reclamation of surface mines and quarries that specifically request *"the post-mining graded slopes must approximate the pre-mining natural slopes"* (United States Code of Federal Regulation, 2002). Of course, exceptions are made based on the approved after use of the site.

Rehabilitation with Backfill

This rehabilitation method is fundamentally adopted when there is a need to alter the landform of the excavated site. Whether the topography is restored to its pre-quarrying conditions or adjusted to another form ultimately depends on the selected site after-use. However, this method enables options both to occur.

Another decision inherent to this rehabilitation method is the choice of backfill material, which can include rubble, inert or non-inert waste, in addition to the site overburden, subsoil and soil layers overlying the excavated or quarried material. Key considerations for the type of fill material include material availability and cost, bulking and settlement characteristics, and site after use.

Low Level or Partial Rehabilitation

When the after-use of the site does not require major changes to the landscape, low level or partial fill rehabilitation can be adopted. In this case, excavated or quarried voids are shaped to landforms appropriate to the topography of the area, while backfilling is kept minimal. Such a method may be appropriate to use in the rehabilitation of an abandoned quarry site, which is to be converted into an amphitheater or a rock-climbing arena.

There has been an increasing trend for this rehabilitation type in various regions in the United Kingdom, despite the fact that it maintains "alien features and breaks in the landscape," which had been introduced from the excavation activity (Surrey County Council (SCC), 2002). However, landscape features such as plants can be used to screen steep breaks and harmonize the landscape.

In the case where the water table is high, and flooding of the quarried site has taken place, wet partial fill restoration can be used, allowing for a wide range of after uses, such as water recreation, wetland or reservoir creation.

3.6.5 Phasing of Rehabilitation

The rehabilitation of extraction sites serves to minimize and in some cases, alleviate the environmental, economic and social impacts resulting from quarrying or excavation activities. The earlier a site is rehabilitated, the quicker these impacts are dealt. Based on the above, phased or progressive rehabilitation is the preferred alternative to rehabilitation that commences only after cessation of all extraction activity and quarry closure. Progressive rehabilitation involves the staged treatment of disturbed areas during the extraction operations rather than undertaking large-scale rehabilitation works at the conclusion of the works. According to the Queensland Government Department of Mining and Energy, the advantages of progressive rehabilitation include:

- satisfying the neighbouring community
- reassuring government agencies and decision-makers
- reducing projects costs and time
- reducing environmental impacts due to minimized soil erosion, water contamination, and visual impacts
- allowing for practical trials of rehabilitation methods prior to widespread use
- maintaining topsoil fertility due to shorter storage time
- improved operations cash flow

According to the (Surrey Country Council (SCC), 2002), the quarry operator can improve the plan of the extraction and phased restoration operations by taking into consideration the following issues (see Figure 10):

- Phased rehabilitation should follow a logical sequence, preferably working through the site and finishing back at the site entrance. In addition, the processing plant and storage areas should be positioned on the last areas to be restored.
- The re-routing of haul roads should be avoided to reduce additional site disturbance. In addition, it is preferable that the haul roads not cross-unstripped or restored soils.
- The areas selected for phased rehabilitation should as far as possible reflect the different soil units to be handled.

- Site planning should aim at increasing the areas with vegetation cover prior to extraction and during rehabilitation since soils are best conserved in that manner rather than in storage.

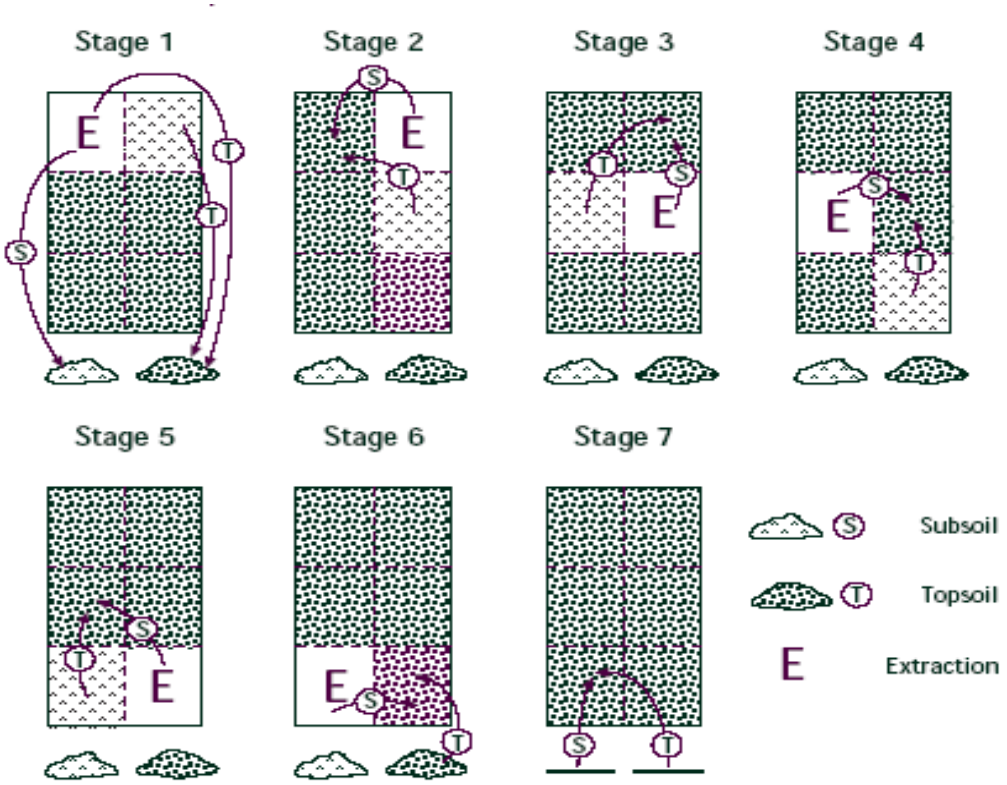


Figure 10 Principle scheme of progressive restoration (SCC, 2002)

3.6.6 Rehabilitation considerations, internal and external factors

As a rule, each quarry site is unique, creating its own site conditions and rehabilitation opportunities. However, there is a set of factors that are usually considered before commencing rehabilitation activities, which determine the best end-use alternative for that site. Some factors cited as affecting the choice of the restoration schemes are listed in Table 13.

Table 13 Internal and external factors affecting restoration schemes
(modified of MIRO, 2006)

Internal factors	External factors
- Climate conditions	- Public Concerns
- Slopes and land surface	- Land use planning
- Site topography of the determined area	- Legislation and Enforcement and land ownership
- Soil characteristics and quality	- Cost Implications
- Geologic formation	- Alternatives for Rehabilitation
- Location of a quarry site	- Budget availability Local public opinion
- Quarry site stability	- Extent of required/desired public access
- Surface water	
- Invasive plant species	
- Site accessibility and re-use	
- Likelihood of Vandalism	

3.6.6.1 Internal Factors

- Climate conditions

Climate directly affects the range of flora that can not only survive, but also thrive, in a site. It is important to select the suitable plant species to achieve sustainable re vegetation results.

Microclimate can limit the growth of sensitive or highly adapted native species if the required conditions are not adequately met. Lebanon's diverse climate, soils and landscape create distinct microclimatic conditions, many of which have not been thoroughly studied. Another contributory factor to successful vegetation growth is aspect.

- Slopes and land surface

South-facing slopes in the Northern Hemisphere and north-facing slopes in the Southern Hemisphere are exposed to more direct sunlight than opposite slopes and are therefore warmer for longer periods. In addition, a sun-facing slope will be more open to sunlight warm winds and will therefore generally be warmer than the opposite slope. As such, the aspect of the dominant quarry face(s) affects the sunlight that the quarry site will receive and the potential for vegetation growth or restoration that the site holds (MIRO, 2006). The aspect

of a slope can also produce significant influences on its microclimate and can have major effects on altitudinal and polar limits of tree growth as well as on the distribution of vegetation that requires large quantities of moisture.

Face height and slope, and the way slope treatment is carried-out affects public safety and the safety of the established end-use. The methodology for slope treatment is diverse and can remedy slope steepness or configuration. It is preferable to decrease steepness and reach ultimate safety and stability when dealing with human use or contact.

- Site topography of the determined area

Although site topography can be dramatically altered through groundwork, it is an important limiting factor when considering savings in rehabilitation cost. The more complex and distant the final desired landscape from the existing quarry state, the more it will cost to achieve. However complex landscapes, such as that of golf courses, are often expected to generate future revenues. Site topography affects other risk factors, such as aspect and mesoclimate, which influence vegetation growth potential. End-uses that are expected to be particularly sensitive to site topography are golf courses, resorts, and open natural theatres.

- Soil characteristics and quality

Soils determine the success of plant growth through nutrient lack or provision. Soil texture helps or hinders the binding of seeds during seeding, and the success of young plants. The quantity or thickness of topsoil should be sufficient for development, and organic matter must be abundant for holding moisture in the soil.

This factor can be easily countered with the addition of supplement organic material, nutrients or soil conditioners to suit the desired end-use. Therefore, with the exception of very poor soils and cases of severe soil erosion or lack of soil cover, this factor has a limited impact on land-use alternatives (MIRO, 2006).

- Geologic formation

The geologic formation of a site, and its stability, affect the potential structures that it can support. The lithology of a site affects its potential for qualifying as a site for artistic sculpture, whereby the softness or hardness of the rock affects the potential of sculpture work and the human and financial resources the task would require. Site geologic formation is also associated with a specific soil type, which affects vegetation growth.

- Location of a quarry site

The location of a quarry site is vital in determining the possibilities of its end-uses (SCC, 2002). Provided that other site conditions are met, sensitive or important ecosystems such as wetlands or endangered habitats or habitats harbouring endangered species, require a buffer zone or neighbouring zone to shield it, and provide an occasional supply of flora and/or fauna through migration. Such ecosystems should preferably be connected to neighboring

ecosystems through green corridors, or constitute such corridors themselves, or otherwise be weak in their isolation.

For sites evaluated for conversion to wetlands for wastewater treatment, the site must be close to and downstream a human settlement generating the wastewater, and must preferable form a slow cascade flow of the water along the wetland.

Sites considered for water storage or reservoir establishment should consider proximity to the agricultural lands to be irrigated or to the expected water sink for feasibility and cost efficiency of water delivery.

- Quarry site stability

The stability of a quarry site directly restricts its options for post-rehabilitation end-use (SCC, 2002). Any alternatives involving construction or repeated human activity must be established on stable grounds. Uses affected by this factor include but are not limited to housing or residential areas, resorts, recreational areas, industrial zones, office parks, and water holding uses such as reservoirs or fishing lakes.

- Surface water

The vulnerability of a quarry site with regard to surface water restricts its end-use options or otherwise imposes firm enforcement of stringent rules and regulations for possible sources of pollution. Where there is uncertainty in enforcement and inspection capacity, less harmful land development alternatives should be sought. Considering that the distance of each quarry site from water springs, rivers, and streams will be known, the risk to surface water can be evaluated. Among the described end-uses, those posing most risk are, in most cases, human settlements (residential, commercial), industrial establishments, resorts and landfills.

- Invasive plant species

The risks associated with invasive species are numerous, as related to plant and animal establishment at a quarry site. Invasive species can alter ecological relationships among native species and can affect ecosystem function, economic value of ecosystems, and human health. The balance of ‘engineered’ ecosystems can be at risk if invasive species are not considered in that area. Endangered species are often sensitive and vulnerable in nature, or live in sensitive ecosystems with a difficult balance to maintain. In cases where such ecosystems are to be established or supported, care should be taken to eliminate invasive species that are more vigorous and dynamic.

- Site accessibility and re-use

The accessibility to a quarry site is a factor either to be remedied if a specific end-use option is desired, or to be considered as a limiting factor. Development alternatives where regular

human access is expected are affected most by this factor, including housing or residential areas, recreational zones, industrial zones, resorts, and agricultural areas.

This factor is critical in determining the suitability of a quarry site for a particular end-use option, particularly development into a water reservoir, a landfill, a human settlement involving piping and sewage networks that include residential areas and resorts, an industrial establishment, and an agricultural area with expected heavy fertilizer use.

- Likelihood of Vandalism

This factor encases the intentional and malicious destruction of or damage to the property that is to be established upon the quarry site, which is referred to as vandalism. It can also encompass illegal and uncontrolled exploitation of a common resource, service, or area (MIRO, 2006).

Vandalism should either be prevented beforehand by physical means such as fencing or dealt with in other ways, but should be accounted for in all cases in Lebanon. Some end-uses, such as housing, resorts, and park offices, are less prone to vandalism than other alternatives. Special care should be taken mostly with alternatives destined for public use or open to public, as water reservoirs, public parks, and forestry.

3.6.6.2 External factors

- Public Concerns

Public concerns are famous for hindering developmental projects worldwide. Amongst the two most known public syndromes are the Not In My Back Yard (NIMBY) syndrome and the very dramatic Ban Any New Activity Anywhere Near Anyone At All (BANAANAAA) syndrome. These two social paranoia pose problems, especially when dealing with quarries, which are a socially, politically and environmentally sensitive issue in Lebanon (MIRO, 2006). Public concerns strongly affect end-uses such as landfills, water reservoirs, and industrial zones.

- Land use Planning

Land use planning and legislation restrict the development alternatives of a quarry site. The official national classification of areas by allowed land use is available from the Directorate General of Urban Planning (Lebanese Laws and regulations), and can be used within the GIS system to identify possibilities for development in each area. As such, every quarry site will have a limited number of end-use alternatives to be selected from.

- Legislation and Enforcement and land ownership

Legislation is linked with land use planning, whereby the developmental possibilities of each area are determined and enforced by law. Legislation will also play a role in relation to land ownership, whereby in cases of full or partial private ownership, the landowner will determine the effective end-use of the quarry site, or otherwise the local authorities will acquire the site.

- Cost Implications

The available budget for development is expected to vary per site, except in the unlikely cases of a national fund or international grant. The end-use must be known or determined before proceeding with rehabilitation activities, even if funding for development is not available. The rehabilitation procedures must be performed once and in a single phase, in order not to make any major changes at a later stage. This involves groundwork, filling, stabilization, and the like, and does not necessarily apply to seeding, planting, or aftercare. In cases where extensive and costly changes are to be made to the site for a particular desired end-use, such costs must be accounted for.

It is imperative that a rough cost analysis be conducted for each site, according to site size and extent of work required for the potential desired end-uses. Based on this estimation, decisions should be made to continue with to reach the desired outcome, by using available funding and/or securing additional funds, or to choose a less costly end-use for the site.

3.6.7 Alternatives for rehabilitation

Quarrying is only a temporary use of land that can last up to several decades. However, the question remains as to what will happen to the site following its exploitation. Addressed prior to extraction, the answer to this question determines not only the method for site rehabilitation but that for the quarrying operation itself. Therefore, prior to any rehabilitation work begins – and even any extraction work, the after-use of a site needs to be proposed by the quarry operator and approved by the competent regulatory agency.

There are many different after-uses into which a quarry site can be rehabilitated. According to (SCC, 2002), these after-uses have been categorized into five broad categories: recreational and leisure, nature conservation, agriculture, development, and other beneficial uses. The choice of alternative however is not a straightforward process. It involves careful consideration of various factors including not only the characteristics of the quarry and its surroundings, but also factors such as the economic feasibility of the selected alternative, local land-use schemes, as well as public opinion. Moreover, the long-term implementation of the use, as well as the entity responsible for the long-term site management and finance should be identified.

Moreover, it is possible to integrate more than one after-use within the same site. This is more common for larger extraction sites which are not very common in Lebanon. Such multi-use or zoned sites are typically larger in size. They are also typically more complex to plan for but have the potential to better suit the existing land-use patterns and surrounding landscape. For example, the nature conservation after-use typically compliments an informal recreational usage such as picnic areas.

Where the operator chooses a restoration method consisting in levelling and re-vegetation of the site or in a landfill made up of earth, sand or stone, followed by surface re-vegetation, 75 % of the guarantee shall be remitted to him after the Minister has ascertained that he has complied with the rehabilitation scheme. The balance of the guarantee is remitted after two years, when the re-vegetation of the land is completed, unless the environmental milieu will not support perennial vegetation.

Where the operator chooses other restoration options, the guarantee shall be remitted to him in its entirety after the Minister has ascertained that the operator has complied with the rehabilitation scheme, insofar as these apply to the restoration plan which has been carried out.

The guarantee shall not be remitted to the operator if it has been used by the Minister. However, if the amount of the guarantee is greater than the cost of the restoration work carried out on the Minister's orders, the balance shall be remitted to the operator.

3.6.8 Costs of quarry rehabilitation in Lebanon

The Cost of Environmental Degradation in Lebanon

In the World Bank Study (World Bank [Sarraf, F. Larsen, B. Owaygen M.], 2004), the cost of environmental degradation in Lebanon was estimated of about 1.5 times higher than high income countries with respect to the various categories involved using various environmental economic techniques.

The report shows that costs of environmental degradation in the year 2000 were estimated between 2.8 – 4.0% of GDP. The annual mean is set at 565$ million or 3.4% of GDP. In addition to Lebanon and at the regional scale, costs of Environmental degradation studies, between year 1999 and 2002, were also carried out in Algeria, Egypt, Jordan, Morocco, Tunisia and Syria. In this regard, Lebanon was ranked best third amongst the various countries (Tunisia with the best COED of about 2.1% of GDP and Egypt with the worst COED of about 4.8 % of GDP).

Table 13 summarizes the estimated results, indicating that air pollution (particularly urban pollution) followed by water pollution (specifically lack of safe potable water, sanitation, and hygiene) are the most serious environmental problems in Lebanon and alarmingly, degradation of Lebanon’s coastal zones is the highest in the region (World Bank [Sarraf, F. Larsen, B. Owaygen M.], 2004).

Table 13 Environmental Degradation Costs in Lebanon by sectors (World Bank, 2004)

Environmental sector	Cost of Environmental Degradation (US $ millions per year)	Cost of Environmental Degradation (% of GDP)
Air	170	1.02%
Water	175	1.07%
Land & Wildlife	100	0.60%
Coastal Zones & Cultural Heritage	110	0.68%
Waste	10	0.05%
Sub-total	565	3.4%
Global Environment	90	0.5%
Total	655	3.9%

Within the context of quarries, the World Bank study did not undertake a thorough assessment as to the damage cost of all existing quarries in Lebanon. However five such quarries were assessed in Mount Lebanon Governorate, where "the loss in land and apartment values (associated with a reduction in aesthetic value) was taken into account." The loss of land and adjacent apartment values around these five quarries is estimated in Table 14.

Table 14 Loss of property value of real estate adjacent to quarries (World Bank, 2004)

Quarry Name	**Decrease in land prices** *(USD million)*	**Decrease in apartment value** *(USD million)*	**Sub-total** *(USD million)*
Nahr Ibrahim quarry	14.00	-	14.00
Shnanaayer quarry	75.00	8.10	83.10
Abou-Mizen quarry	1.31	-	1.31
Antelias quarry	5.00	0.75	5.75
Nahr El Mawt quarry	(Industrial zone, no impact on land prices)		-
Total	**95**	**8.85**	**103.85**

However, these surveyed quarries are considered among the most important in the country in terms of deterioration of landscape as some border high-density urban coastal zones and popular inland locations. Therefore extrapolating these values nationwide to cover the more than 700 quarries is not an option (World Bank Sarraf et al., 2004).

As a conservative estimate, the World Bank study indicated that the cost of environmental degradation corresponding to more than 700 quarries in Lebanon is about USD 48 million. This however is overly conservative, as it is solely calculated as the value of the land that those quarries occupy. Added with the five above-mentioned quarries in Lebanon, the annual damage costs would amount to a conservative USD 14 – 16 million, or 0.1% of GDP (World Bank Sarraf, et al., 2004).

To place things in perspective however, calculating the cost of environmental degradation of quarries is also subject to much uncertainty and variation depending on the technique used for calculation and the assumptions taken.

In one study (Harajli, 2005), the contingent valuation method (CVM) was utilized to calculate the cost of environmental degradation from one important quarry located near the historic Moussielha Castle in Northern Lebanon, in order to assess the mean and total willingness-to-pay for rehabilitation. CVM and its survey techniques are used to estimate the economic value of commodities and/or services which are not traded in the market place. Therefore for such commodities is a lack of any prices. CVM involves asking a randomly chosen sample of people what they are willing-to-pay for a clearly defined change of a good or service. Furthermore what people are willing-to-accept or tolerate a change (World Bank 2005).

A survey composed of two-hundred questionnaires was carried out in regions both neighbouring the castle and considered some distance from it, asking people (through random sampling) face-to-face their willingness-to-pay to rehabilitate the quarry of Moussielha based on a hypothetical scenario and assumptions given below, and based on a simulated picture of the Moussielha quarry rehabilitated.

The results obtained indicated that the median WTP for rehabilitating the Moussielha Castle quarry was found to be US$23, which led to a total WTP- willingly to pay (or total value towards rehabilitating the quarry) of US$11.3 million, while that of rehabilitating all quarries in Lebanon amounted to a median of US$43 per year, which totaled to US$21.2 million per year, or a range between US$212 – US$318 million over 10 to 15 years or the time it would take for rehabilitating all quarries (Harajli, 2005).

The study itself indicated the uncertainties, limitations and necessary assumptions involved, and proceeded throughout as conservatively as possible. With all this, the annual value for the rehabilitation of all quarries in Lebanon was calculated to be over USD 21 million. However herein it is important to note that not all quarries would need rehabilitation depending on the size, shape, location, and type of quarry and the effectiveness and time frame of natural factors like weathering and re-vegetation.

It was estimated in the Dar Al Handasah report that the additional costs to quarry operators for implementing policy measures that will suppress dust, reduce noise and vibrations, in

addition to rehabilitating the quarry site is equal to US$0.71/m^3. The US$0.71/m^3 value of Dar Al Handasah is for the year 1996, equivalent to US$0.87/m^3 in today's terms (since the average inflation in Lebanon for the past 10 years is about 2.1%), encompasses noise and dust suppression and not only rehabilitation.

The survey done by the Dar el Handasah indicated that very little activity toward rehabilitation is taking place and that the greater majority of quarries in the country remain in a condition which has a detrimental effect on the landscape (out of the 280 quarries surveyed by the study, there were no plantation in 98.5%, no restoration in 99.6% and no natural regeneration in 98.4%)

3.6.9 Mining and sustainability

Sustainable mining/quarrying

This term, which some may dismiss as an oxymoron, could also be viewed as an important objective to sustain mining/quarrying (please refer to section 2.3.2) dependent communities into the long term, well after the quarry itself closes.

Resources development however is often accompanied by social and biophysical costs.

The first steps towards achieving the long term sustainability include the development of principles of sustainability and a resource management approach that supports those principles. Once this is achieved it is possible to conduct a gap analysis between the principles and practices of sustainable quarrying and the present state of the mining region/s. this analysis then lends itself to the identification of barriers and opportunities that must be considered in the quest for a more sustainable future for the quarrying communities.

Principles of sustainability

Sustainability entails the realization of human needs and rights, while maintaining the natural integrity of biophysical systems that support anthropocentric activities over the long term (Robinson *et al.*, 1990). Healthy human communities are an integral part of sustainability. Human needs and rights include a wide range of requirements that must be recognized, such as adequate food water and shelter; economic stability; cultural fulfillment; and meaningful participation in the political process and decision making (United Nations, 1992; Gibson, R.B., 2002; Robison *et al*., 1990; Gardner, J., and Roseland, M., 1989; Schrecker, T., 1999; Sen, A., 1999) . Sustaining biophysical systems includes protecting genetic and species diversity in plants and animals; protecting ecosystems functions and adoptive preventative solutions rather than end-of-pipe mitigation of pollution. (Hawken *et al.*, 1999; Kay *et al*., 1999; United Nations, 1992). Some essential principles include maintaining biophysical integrity, social vitality, and economic self-sufficiency (Kay *et al*., 1999).

Impact of Mining on sustainability

Mining as practiced in most parts of the world fails to meet the above principles of sustainability. This is particularly the case in economies that rely on development to sustain immediate human needs. In part, the difficulty is inherent in the nature of the activity itself. Every mining operation is recognized as causing two immediate effects on the surrounding environment. The first effect is the depletion of the natural resources base (natural capital) during the lifespan of the mine (Cavalcante, R.N., 1995) and the second is the negative biophysical impact of the mining activities. While the mine is operating, there is a constant depletion of the natural capital available to the region or the country within which the mine is operating. As the mineral is extracted and sold the total amount of the natural capital available to the region is diminished. The end result of this process is the total removal of the mineral resource, leading to the closure of the mining operation.

It is the nature of mining to remove the resource base. Minerals are not renewable and cannot be replaced within one generation (Cavalcante, R.N., 1995). Some minerals however can be reused through recycling, making the product more sustainable over a longer term (IIED and WBCSD, 2002).

Mining related activities can also run counter to several of the principles of sustainability. The reduction of a region's natural capital without adequate restorative measures reduces both the biological diversity of species as well as the regenerative capacity of ecosystems (Ripley *et al.*, 1996).

The disturbance of the biophysical environment through mining processes (exploration, extraction, processing and transportation) is related to the size of the operation, as well as the type of mining being pursued, and the ecological sensitivity of the surrounding biophysical environment (Ripley *et al*., 1996). However, the results of any mining operation, if unmitigated, can include damage to the aesthetic characteristics, hydrologic systems, atmosphere, flora and fauna, fertility of soil, as well as human health.

Defining a sustainable mining region

The general problem is that the activities of mining are contrary to the principle of sustainability. The industry is often characterized by environmental degradation, negatively affecting biodiversity and regeneration of ecosystems. Mining in any community or region is a temporary economic activity, and cannot in itself be considered sustainable over the long term. It is possible, however, to conceive of a mining region being sustainable in terms of long term health beyond the life of a mine (Veiga *et al*., 2001).

The following is offered as working definition: a sustainable mining region is one that uses mineral extraction to enhance and diversify community development beyond the life of the mineral resource, while maintaining the health of the biophysical environment, and

eliminating negative social and cultural impacts of mining on the local population, over a multigenerational time scale.

To achieve this goal, a number of prerequisites, including political will, must be in place. A sustainable mining region must balance the views and influences of stakeholders and decision makers that range from global to local.

Sustainable development and mining

While decision maker in many industries can select a location and then often move their operation there, the location of a mine is fixed by an existing mineral deposit. Once a mining company as invested development capital, it cannot easily move its mining operation. Furthermore, as VicKerman notes:

"*Despite the economic benefits that mining and metals bring to societies, it is the environmental and social consequences of the mining activities, whether real or perceived, that attract greater attention*" **(**VicKerman, A., 2001)**.**

Nowadays mining companies must meet the rising expectations of costumer, consumers, civil society and public authorities and by compliant with existing rules and regulations by improving their contribution to the development of societies and their surrounding natural, social and economic environments.

Integrated mine planning for sustainable development

It is now generally agreed that the earlier a mining company or a miner incorporates integrated environmental and social management into its closure planning, the more cost effective and efficient it will be. The most effective planning for closure incorporates active technological and organizational innovation, rather than reactive behaviour, which often leads to more costly incremental technological changes. Best practice generally involves implementing appropriate operational and environmental technologies and social development strategies during the initial stages of mine construction. Figure 11 describes what sustainability involves being the cross cutting issue of different means preserving the natural resources.

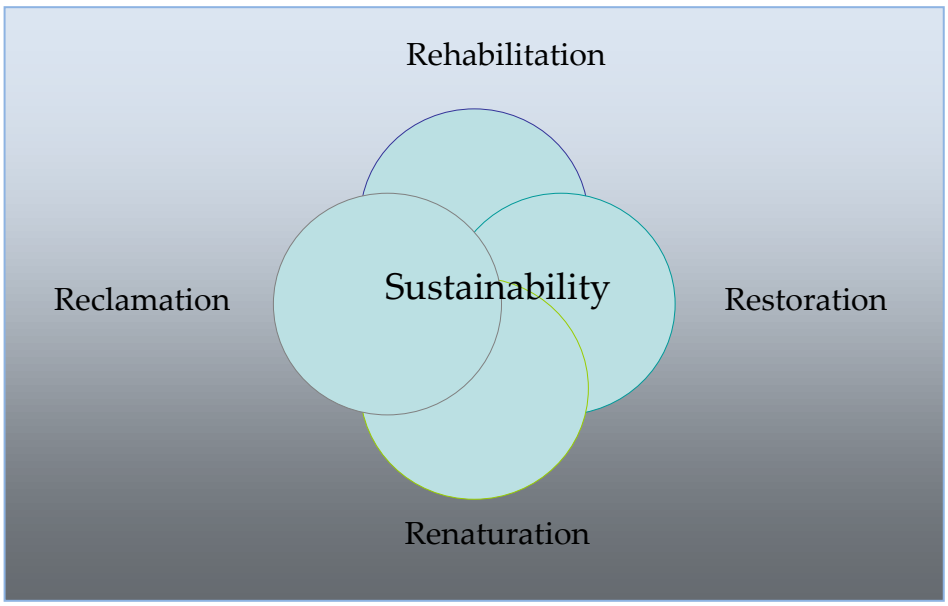


Figure 11 Definition used for sustainable management of quarries

4. RESEARCH AREA AND PILOT PROGRAMME AND METHODOLOGY USED

4.1 Characterization of the investigated mines and quarries

In order to specify the status of quarry rehabilitation, based on the general overview about the quarries locations (Table 8) investigations were necessary in order to evaluate the rehabilitation status. In the first phase of the studies a desk survey was carried out. Following sources were used for analyses and evaluation of the quarries existing in Lebanon:

1) A quarry data sheet was prepared including relevant information and details required to monitor the management and rehabilitation of quarries in Lebanon.
2) The data in the study of Dar Al Handasah 1996
3) Data available from former satellite imagery for Lebanon as a satellite data collection in frame of the project Ikonos (2005) for the following reasons:
    - Identification of quarry number and distribution
    - Assess other types of parameters (e.g. geographical coordinates for each quarry location, distribution of quarries per villages/Caza, etc...)
    - Lead the site survey in the appropriate manner through preparation of field survey plan (locations to be visited)
    - Assess the environmental base line data for Sibline quarry in pre and post excavation phases.
4) Ministry of Environment quarries Database
5) Computer and software equipments, Google Earth Application 2007, digitizing work, GIS layers (e.g. geology, hydrogeology, land use land cover, protected areas, soil, cadastral, villages, river, contour lines 50 m interval – 1963; quarry map (map # 1 of the decree No. 16456)
6) Equipments needed to conduct the field surveys (e.g. compass, maps, GPS devices, digital camera, topographic maps, etc…) that were done to the possible extent in order to cover the quarries to be surveyed
7) On-site investigation and assessment – site survey; before, during and after rehabilitation

Different several remote sensing parameters collected based on the mentioned programmes were investigated in order to classify the general quarry type, land use and stage of renaturation and rehabilitation (Table15).

Table 15 Parameters collected in frame of the remote sensing project (Ikonos, 2005)

Information about general structure	Information about current situation or activities
- Geographical coordinates	- Clusters (y/n)
- Geographical conditions	- Distance to water resources
- Administrative position	- Natural Land use
- Land form type	- Rehabilitation Activity
- Type of Quarry (Rock or Sand)	- Renaturation status

Additional to the data base of the remote sensing project, the data from the Geographical information System (GIS) was used. The collection of GIS data from various sources including land cover types, land use types, hydrogeology, types of geologic formations, soil types allowed to assess several other parameters:

- Geologic Formation
- Hydro- stratigraphic Formation
- Soil Type (sand, clayey sand, clay, sandy clay etc.)
- Land use type
- Cadastral assignment

In the second phase a field survey was carried out in order to evaluate the different parameters collected for the quarry data sheet.

Based on this survey it was possible to have an own view about the current quarry characteristics (Table 16).

Table 16 Distribution and number of quarries surveyed in field

Governorate *(Mohafaza)*	**Estimated number of Quarries**	**Number Quarries Surveyed**	**Number Quarries Surveyed (%)**
Mount Lebanon	247	160	66
Baalbek-Hermel	159	80	52
Bekaa	113	65	58
North Lebanon	109	67	62
South Lebanon	76	48	63
El Nabatieh	72	51	71
Total	776	471	61

These phase were important on one hand to check the available data about the quarries in Lebanon and to correct them and on the other hand to have an own overview about the different types of quarries and their status of rehabilitation The most important data are shown in table 17. In connection with this survey one quarry was selected for the pilot project of rehabilitation.

The intention is to use this pilot project as a case study, for further multiplication of the results if the quarries are similar. For this purpose was selected the Sibline rock quarry in Chouf area in the governorate Mount Lebanon. The rehabilitation of Sibline quarry was planned in the way of by backfilling it with the leftover inert materials transferred from the Normandy landfill and used it for agricultural purposes as part of the envisaged post closure plan for Sibline quarry.

Table 17 Information collected in the field survey from quarries in Lebanon as random sample

Field	Description
Land Ownership	Public or Private
Quarry Activity	Active; Non-Active
Quarry Type (general)	Rock or Sand
Quarry investment	Decorative; Mosaic; Cement; Sand & Natural Aggregate; Crushed Stone; or Industrial Sand
In selected districts	UTM Reading taken by GPS in Field
Soil pile	Presence of overburden / soil piles in site: Yes / No
Face height	Indicates average height of quarry face (m)
Visual impact/influence	Negligible; Low; Moderate;High; Extremely High
Ecology impact/influence	Impact on fauna and flora Negligible; Low; Moderate; High; Extremely High
Site existing vegetation Cover	Absent Cover; Few (+) <10% Cover; 11-24% Cover 25-49% Cover; 50-74% Cover; >75% Cover
Site existing vegetation height	Vegetation Height <0.5m; 0.5-2m; 2-4m; >4m
Status of rehabilitation	No Rehabilitation; Partial; Complete
Type of rehabilitation	Terracing, renaturation/revegetation

4.2 Methodology of investigations and research

As already mentioned (see 4.1), the research consisted of three components

- an in-depth desk survey complimented by
- a field survey of stratified sampling nature and
- a pilot case study on how to do a rehabilitation.

For this purpose, the research approached the issue of quarry rehabilitation based on several methodologies.

4.2.1 Physical methods

The physical method used can be divided in three activities:

1) Preparation of individual Quarry data sheet: for the purpose of the research study and based on extensive consultation as well as feedback from experts, an quarry data sheet was prepared for each quarry to identify the relevance of existing quarries in respect to their rehabilitation status (see Appendix F- Quarry data sheet);

2) The field component of the survey also consisted of several sub-components. These included:

    - Preparation of Field Survey Plan: the methodology of the field survey included: the locations of the selected quarry sites, the backgrounds of the survey team members, and the extent of the site investigation.

    - Team expert: the team included a multidisciplinary group of expert from different scientific background: agricultural engineer, geologist, and civil engineer. Prior to the mobilization of the survey, the team of expert was briefed on the research aim and the parameters to measure in order to be able to assess the rehabilitation status of the quarries investigated.

    - Equipment and Survey Logistics and map preparation.

4) Analysis of quarry characteristics: several parameters were collected at this stage including general quarry type, land use, as well as other parameters.

4.2.2 Use of the Geographic Information System (GIS)

1) Remote sensing of quarry distribution through satellite imagery: using a GIS tool, a desk survey of high definition satellite images (60-80 cm) was conducted. In this way all sites of quarries or otherwise visible on the digital map were scanned and their geographical location (coordinates) and some of their characteristics were also identified.

2) Gathering and analysing additional data (GIS Database): the different layers of collected data were linked together using GIS tool (MapInfo professional 8.5 SCP, Arc Map 9.0 by ESRI). GIS was used to integrate georeferenced imagery as data layers as well as to link them to other data sets to produce geospatial representations of data in order to identify some measurable characteristics of quarry rehabilitation concern.

3) Collection of GIS data from various sources including land cover types, land use types, hydrogeology, types of geologic formations, soil types.

4) Analysis of quarry characteristics surveyed during this stage.

4.2.3 Environmental-Biological methods

The study adopted the DPSIR (*Driving forces, Pressure, State, Impacts and Responses*) Model as an Ecological Method for the pilot case study on how do the rehabilitation of an old quarry being one of the frameworks that reports the state of the Environment and its impact on biodiversity as used by the European Environment Agency (EEA) in the European Union. Whereas **D**rivers referring to the external forces; **P**ressures are the consequences of the driving forces; **S**tates mirror the pressure; **I**mpacts are the resulting effects; **R**eponses are the actions from society.

The DPSIR Model, adopted by the European Environmental Agency, is one of the frameworks based on the concept of causality chains for data synthesis, which links environmental information using indicators of different categories (UNEP/RIVM 1994) **(**RIVM, 1995) as shown in Figure 12. This model is similar to the PSR framework (OECD, 1993), but with two more categories: *Driving forces* and *Impacts*. The first reports to the "needs" of individuals and institutions that lead to activities that exert pressures on the environment.

Driving forces are understood as the social needs that require the existence of a given economic activity. The "intensity" of the *Pressure* depends on the nature and extent of the *Driving forces* and also on other factors which shape human interaction with ecological systems. The *Impacts* are related to ecosystems and human health due to *State* modifications. The policy *responses* lead to changes in the DPSIR chain.

In short, *driving forces* refer to the external forces (e.g. social, demographic and economic etc) which can influence human activities (e.g. life style). *Pressures on the environment* are the consequences that the change of human activities can bring on the environment. *Pressures* can be either increased or mitigated under the function of the external forces. *States* mirror the pressures and are the reflections and conditions of *pressures* on the environmental status, usually in a quality perspective. *Impacts* are the effects after environmental degradation. *Responses* are the feedback and actions from society with attempt to prevent, compensate or change the previous problems.

A thorough understanding of the problem of quarry rehabilitation, its related driving forces and resulting impacts at various levels are essential before problem-solving efforts are taken. Many methodologies, e.g. DPSIR framework can be applied to depict the problem. Its major

application is on assessing and managing the environmental problems related to sustainable development therefore is useful for policy-makers.

Besides, with DPSIR framework, all related parts within the system, e.g. driving forces, pressures, state, impacts and responses together with their inter-collected causality can be discovered and identified. The ultimate goal of DPSIR framework is to evaluate the effectiveness and efficiency of the policy responses (EEA, 1999).

EEA states the aim of such an approach is:

- To be able to provide information on all of the different elements of the DPSIR chain
- To demonstrate their interconnectedness
- To estimate the effectiveness of the responses

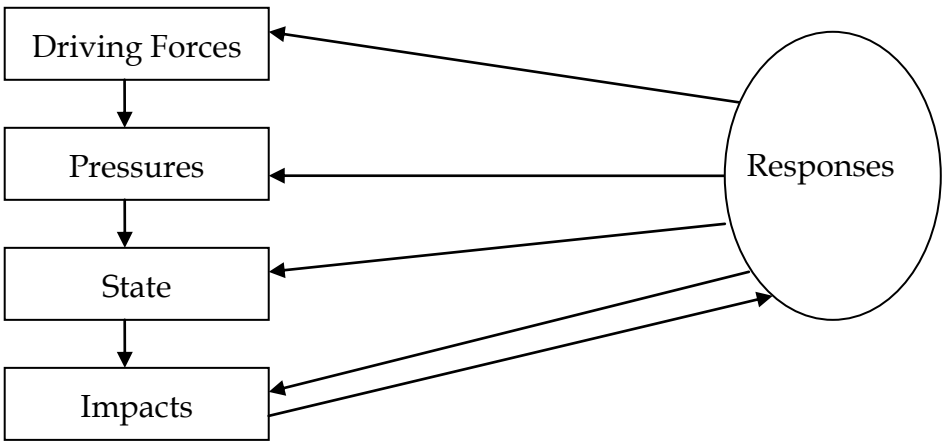


Figure 12 Conventional *Driving forces, Pressure, State, Impacts and Responses* (DPSIR) scheme

5. DESK AND FIELD SURVEY- CURRENT SITUATION OF QUARRY MANAGEMENT IN LEBANON

Given the severe limitation of Lebanon's resources and its current macroeconomic situation, any government expenditure needs to be thoroughly justified and prioritized. The cost of environmental degradation due to abandoned quarries not only illustrates the magnitude of the damage, but it generates a valid economic justification for intervention.

However estimating rehabilitation costs is necessary to undertake for two primary reasons. The first and foremost reason is that the necessary budget to be allocated for rehabilitation needs to be clearly known (i.e. how much money is required from the national or local authority budget – for example- for the rehabilitation of the quarries?). The second reason is that the rehabilitation costs should not exceed the environmental damage costs (costs of environmental degradation of respective abandoned quarries), or else there would be no economic (and arguably environmental) justification for rehabilitation to take place. An approximation of the rehabilitation costs of abandoned quarries in Lebanon would be undertaken mainly through indications in the available literature and through transferring values from outside studies.

It must be noted that the calculation of the cost of environmental degradation as well as that of rehabilitating abandoned quarries are subject to much uncertainty and limitations. However both estimations are imperative to describe the problem to policy-makers in economic terms and to predict the resources needed.

On the other hand and in respect for reintegration of quarries into their landscape, there is no universal rule/answer on how to restore and rehabilitate a quarry. Each site is unique and represents a more or less an individual case. The possibility of reintegration of the quarry into landscape depends largely on the type of quarries.

In general quarries in Lebanon are of hillside or mountainous nature. Due to this fact, all rehabilitation options should therefore be consequent to the quarries nature. Major points to be considered are the restoration of rocks faces and the control of rainwater discharges. For sharp cliffs, stability of the rock faces and safety measures have to be looked at carefully.

5.1 Results of Desk survey using the result of Remote Sensing

The numbers of the quarries based on the remote sensing activity (Ikonos, 2005) are different to the database of the ministry and the study of Dar Al-Handsah (1996). The number of quarries in the governorates of Lebanon (see table 8) is much higher as given in the mentioned documentations (Table 18). The reason can be that the survey using remote sensing makes no difference between abandoned, non-active and active quarries. Nevertheless based on this data it is possible to understand the problematic of rehabilitation strategy for

these quarries. On the other hand this difference in numbers of quarries (desk survey and remote sensing) makes clear the need of a field survey.

Table 18 Quarry distribution by Governorate/*Mohafaza* based on remote sensing

Governorate *(Mohafaza)*	**Number of Quarries**	**Number of Quarries (%)**
Mount Lebanon	247	31.8%
Baalbek-Hermel	159	20.5%
Bekaa	113	14.5%
North Lebanon	109	14%
South Lebanon	76	9.8%
El Nabatieh	72	9.3%
Total	776	100%

The remote sense method has his limitations, but nevertheless useful data can be recorded e.g. regarding the distribution per type of geological formation (Table 19).

Table 19 Quarry distribution per type of geological formation based on remote sensing

	Sandy	**Rocky**	**Unknown**	**Total**
Total No of estimated quarries	207	479	90	776
No of estimated quarries (%)	26.6	61.8	11.6	100

5.2 Results of the field survey

A total of 471 of quarry investigations were conducted of the total of 776 estimated numbers of quarries based on the results of the remote sensing (see also Table 16). It could be recognised differences between data of the desk surveys the remote sensing and the own field survey. It was clearly visible it is necessary to visit all quarries in order to collect right and useful information. In the following tables are demonstrated such differences between the official data base and information about the quarries the field survey. On important question in order to develop a strategy for rehabilitation and in particular renaturation was regarding the activity status of the quarries (Tables 20).

Table 20 Number of quarries regarding their activity status

Quarry Activity	Number of Quarries Surveyed	Number of Quarries Surveyed (%)
Active quarries	195	41.4
Non-active quarries	276	58.6
Total	471	100

There are also differences in the numbers of quarries regarding their geological formation, comparing the official data from Dar Al-Handasah (1996) (Table 5 and 6), remote sensing (Table 19) and the own field survey (Table 21).

Table 21 Quarry distribution per type of geological formation based on field survey

Quarry type	Number of Quarries Surveyed	Number of Quarries Surveyed (%)
Rock	366	77.7
Sand	105	22.3
Total	471	100

Very important from economical point of view is the knowledge about the specific type of aggregates which can be excavated from the quarries. Also in this regard were discovered other materials and different amounts (Table 22) in comparison to the official data base from the ministry of environment of Lebanon (Table 10).

Table 22 Quarry type regarding the material mainly excavated based on field survey

Type of material	Number of Quarries Surveyed	Number of Quarries Surveyed (%)
Rock quarry with crusher	252	53.5
Sand for industry	88	18.7
Decorative stones	85	18
Sand and natural aggregates	17	3.6
Mosaic quarry	16	3.3
Cement quarry	13	2.7
Total	471	100

The following results of the field survey were not collected before. The quarry research showed for good quarry management practise there is necessary also information about:

- Socio-economic data as
    - Land ownership;
    - Visual impact
- Physical and geo-biological data as
    - Design of quarries, Face height
    - Ecology impact
    - surrounding site cover
    - Status of Rehabilitation
    - Type of Rehabilitation

From the Socio-economic point of view the ownership of the relevant quarry is very important for their planning, management of excavating and in particular for the rehabilitation procedure. Most of the quarries are private (Table 23) a smaller percentage is belong to the public sector, but for 8.5% of the quarries the ownership is unknown.

Table 23 Land ownership of places with different quarries following the field study

Quarry ownership	**Number of Quarries Surveyed**	**Quarries Surveyed (%)**
Private	406	86.2
Public	25	5.3
Unknown	40	8.5
Total	471	100

Another effect of quarries is to consider from economic point of view this is their visual influence on the landscape. Quarries which are clearly seen from roads, residential, touristic and protected areas can have a negative impact. Therefore the impact of quarries on the landscape should be classified in five categories (Table 24).

Table 24 Visual impact/influence on the landscape investigated during the field study

Visual impact	Number of Quarries Surveyed	Quarries Surveyed (%)
Negligible	44	9.3
Low	89	18.9
Moderate	60	12.7
High	120	25.5
Extremely high	158	33.5
Total	471	100

There are several physical and geo-biological data necessary in order to evaluate the quarry management. One important is related to the design of the quarries. There are regulations regarding the maximum height, in particular with the aim to secure the stability of the relevant quarry type. In Great Britain are detailed descriptions about face heights and safe working practices (Quarry regulation, 2011). The face height in the surveyed quarries was mainly between 21 and 50m, ther were also very small quarries with a face height below 10m and very high with more the 101m (Table 25).

Table 25 Face height of the quarries investigated during the field study

Face height	Number of quarries surveyed	Quarries surveyed (%)
0-10m	90	19.1%
11-20m	137	29%
21-50m	151	32%
51-100m	68	14.4%
>101m	20	4.2%
Irregular	5	1.3%
Total	471	100%

In connection with the main aim of the research the sustainable renaturation was studied the impact of the surveyed quarries on the environment. Therefore the impact or influence on the environment was investigated in five assessments (Table 26). These assessments are values for the impact of quarries on the surrounding ecology with a buffer zone (sampling area) of 100m around the quarry site.

Table 26 Ecology impact/influence of the quarries investigated during the field study

Ecology impact	Number of quarries surveyed	Quarries surveyed (%)
Negligible	25	5.2%
Low	75	16%
Moderate	101	21.5%
High	241	51.2%
Extremely high	29	6.1%
Total	471	100%

Another important parameter in order to evaluate the site covers (Table 27). This parameter evaluated the surrounding site cover of the quarry nearby virgin land by surveying a buffer zone (sampling area) of 100m around the quarry site.

Table 27 Site cover of the quarries investigated during the field study

Site cover	Number of quarries surveyed	Quarries surveyed (%)
Absent	164	34.8%
<10%	37	7.8%
11-24%	21	4.5%
25-49%	18	3.8%
50-74%	65	13.8%
>75%	34	7.2%
Few cover	132	28%
Total	471	100%

In this survey were investigated the current status of the quarry rehabilitation (Table 28). In this case were evaluated the active quarries, that means they are partly still in function or just finishing the excavating of the relevant aggregates. In this table is very good visible the why it is necessary to do this research related to rehabilitation of the quarries in Lebanon. A high number of the quarries with 86.2% are not rehabilitated even following the contracts includes in most of the cases such rehabilitation programme.

Before starting with this survey it was expected to find a high number of not rehabilitated quarries, but the reality shows that the situation is much worse than expected. This result is demonstrating the need to improve the quarry management from the contract to the rehabilitation procedure.

Table 28 Status of quarry rehabilitation investigated during the field study

Status of rehabilitation	Number of quarries surveyed	Quarries surveyed (%)
Not rehabilitated	406	86.2%
Partially rehabilitated	61	13%
Rehabilitated	4	0.8%
Total	471	100%

Additional to this survey were investigated the status of quarry rehabilitation belong to the group of non-operational quarries (Table 29). The discussion about the rehabilitation programmes starts especially because the environmental problems coming from the already non-operational quarries. After the survey the expectation regarding this problem becomes true, only 38.1% of the whole amount of the non-operational quarries in Lebanon is partially rehabilitated and only 2.5% are completely rehabilitated. There are necessary decisions in

order to complete the rehabilitation of these non-operational quarries, mostly in form of renaturation.

Table 29 Type of rehabilitation (of the 160 non-operational quarries in Lebanon) investigated during the field study

Status of rehabilitation	Number partially rehabilitated (of 160 in Lebanon)	Partially rehabilitated (%)	Rehabilitated	Rehabilitated (%)
Terracing, renaturation, revegetation	56	35	4	2.5
Only terracing, incomplete revegetation	5	3.1	-	-
Total	**61**	**38.1**	**4**	**2.5**

Discussion

Based on the aforementioned results it is explicit that no proper rehabilitation had been adopted until nowadays. Results of the quarry site survey of 61% (=471) of the total estimated number of quarries from the desk survey (=776) demonstrated the following details (see Tables 20 to 29):

1. the majority of quarries in Lebanon (77.7%) are of rocky type and the remaining 23.3% are of sandy type;
2. the higher percentage of quarries in Lebanon is committed for the operation of crushed stone quarries with a percentage of 53.5%;
3. more than the half of the site surveyed quarries were non-active on the date of the site survey;
4. Mount Lebanon and Bekaa are respectively the most tow Governorate/*Mohafaza* populated with quarries (34% for Mount Lebanon and 30.7% for Bekaa);
5. more than 86% of the site surveyed quarries are operational in private proprieties,
6. for rehabilitation purposes, the site survey indicated the presence of soil pile in 56.5% of quarries controlled;
7. the highest percentage (32%) was given for the quarries with a face cut height ranging between 21 m to 50 m;
8. 25.5% (the highest percentage) of the surveyed quarries had extremely high visual intrusion on neighbouring regions;
9. 51.2% (the highest percentage) of the surveyed quarries had a high negative impact on the surrounding ecology (fauna & flora);
10. 34.8% of the surveyed quarries are existing in regions where the site cover is absent but the remaining percentage 65.2% indicates that quarries do exist in various regions where the site cover ranges from < 10% to >75%;

11. 86.2% of the site surveyed quarries were not rehabilitated, 13% were partially rehabilitated and only 0.8% of the total number was rehabilitated.

Although there is difference in time scale, if we compare the data extrapolated from the site and desk survey with the data source of both the Ministry of Environment and Dar el Handasah study (1996), it is obvious that many criteria matches in the three data source and more specifically in respect to the following criteria:

1. the largest number of quarries is geographically located in Mount Lebanon Governorate/*Mohafaza*;
2. rock quarries with crushers are taking the biggest part in Lebanon;
3. aggregate quarries are often situated in urban districts in order to lower transportation costs;
4. illegal operations are still taking place due to the lack of proper law and regulations reinforcement;
5. almost no rehabilitation or only partial rehabilitation do exist in Lebanon.

5.3 Administration of quarry management in Lebanon (Quarry Master Plan)

The establishment of the Ministry of Environment constituted in year 1993 a concrete landmark step ahead towards the organization of various environmental portfolios comprising the quarries file. Since its initiation, the Ministry of Environment had issued three specific decrees for quarries as well as many other related Ministerial decisions (see *Appendix A*) that outlined the technical and regulatory framework for organizing this sector.

The above mentioned decrees aimed at laying the way towards the creation of a fundamental set up regarding the quarry sector in its five dimensional levels: technical, legal, administrative, institutional and financial. In fact the Ministry of Environment, succeeded in the last amendment, namely the decree 16456/2006, in addition to the many positives issues already decided by the other decrees, to

- organize the use of explosives,
- identify, in addition to the 4 approved investment areas for licensing, the non-investment areas where investment is prohibited;
- require the supervision, of all quarrying activities, by a civil engineer/hydro-geologist/geologist
- organize the Land Settlement and Reclamation issue (*Appendix G*) .

The Decree No. 8803/2002 and its amendment is the main explicit decree regulating quarries operation and management in Lebanon. Its last amendment was done in year 2006 by promulgating the decree No. 16456. New regulations had been appended to this decree requiring new quarry owners/operators to rehabilitate their sites before they can apply again for a new permit (*Appendix H*);

On the other hand, it should be noted that since 1993 till to date the Council of Ministers reconsidered studying the issue of the quarry master plan and the same council was assigning the Ministry of Interior and Municipalities to issue a document the so called "Administrative Extensions" (Government of Lebanon, 2007). Based on that, too many difficulties are still hindering the implementation of the proper legal framework and are making the task of organization this sector a difficult one to achieve due to the major following reasons:

- The quarry sector is by far the most politicized file amongst the environmental portfolios;
- The concerned authorities in Lebanon did not and could not take a definitive decision in approving the final version of the quarry master plan;
- Although the government made several consecutive endeavour to amend the 4 regions designated in both decrees No. 8803/2002 and 16456/2006, **these regions are still not the most suitable areas for extraction in Lebanon due to**:
    - small surface areas (Government of Lebanon, 2007) (Table 30),
    - located in the western side of Anti-Lebanon chain of mountain,
    - land property tenure,
    - absence of service and access roads,
    - not operational in winter time due to bad climates conditions,
    - high transport cost,
    - concentrated in one administrative Governorate/*Mohafaza* and
    - till to date only two application is presented in the 4 regions (Table 30).

Table 30 Area of the 4 regions approved for quarry investment by decree No. 8803/2002 and all its amendment

Region in Bekaa Governorate/*Mohafaza*	Surface area in m^2
Aarsal	88.72
Tfeil	70.28
Kousaya/Deir El Ghazal	3.508
Rashaya	9.703
Total area	**172.211**

- The overlapping of authorities namely between the ministry of Environment and the ministry of Interior and Municipalities as well as other lines ministries (Appendix A);
- The continuous release by the Ministry of Interior and Municipality of the called "Administrative Extensions" upon the approval of the Council of Ministers consecutive decisions. Usually not based on neither proper administrative and intuitional nor technical criteria, these administrative extension are defined as a shortcuts bypassing the law allowing the investors to work almost anywhere for a short period of time (three months

each time subject for renewal) without respecting environmental conditions and/or financial deposit and/or rehabilitation practices;

- Presence of and unlicensed quarries. The last studies showed that there are approximately 272 reported tickets for unlicensed quarry operations (Table 31) (Government of Lebanon, 2005, 2006, 2007).
- Environmental engagement is not yet considered as the high priority to Lebanese leaders and commanders;

Table 31 Reported numbers of unlicensed quarry operations tickets (Government of Lebanon, 2004, 2005, 2006, 2007)

Governorate /*Mohafaza*	Year			
	2004	2005	2006	2007
Bekaa	58	85	44	53
North Lebanon	1	-	-	-
Mount Lebanon	7	2	6	7
Nabatieh	8	-	-	
South Lebanon	-	-	1	
Total	**74**	**87**	**51**	**60**

- Usually, the land lord is not at the time the investor/company who careless about the land after excavation;
- Most of the mining operations activities in Lebanon are small (artisanal) to medium size enterprises. They lack technical mineral knowledge and financial resources disabling them to continue their investment in a proper way in terms of capacities to sustain their quarries (i.e. lack of mining engineers).
- The level of participation of many miners/investors is determined by availability of deposits, ease of mining, processing and extraction of the commodity, and access to markets, geographical location, technologies used in mining operations.
- The effective participation of miners in the industry sector is hampered by their lack of technical business and management skill, and by their limited access to mineral deposits, capital and market.

5.4 Evaluation of the current situation in quarry management

5.4.1 Sustainability of mining regions, weaknesses and opportunities

5.4.1.1 Weaknesses related to sustainable quarry management

The mining region faces many barriers related to the goals of biophysical integrity, social vitality and economic sufficiency, as do other mining regions around the world. These barriers include the non-approval of the quarry master plan, continuing biophysical degradation from abandoned mines and current practices, economic challenges, limited enforcement capacity and social inequity.

- Abandoned mines and cumulative mining impacts

As is the case around the world with abandoned sites, one of the major problems is accountability. Many investors responsible for major environmental problems during the past 25 to 30 years have closed or moved away. Determining who is responsible for the clean up is a serious barrier to any remediation attempts. The fact that investors take no responsibility for damage done is a significant barrier to restoration. The difficulty in holding anyone responsible for environmental damage represents a large gap among the necessary preconditions for a sustainable mining region, as remediation is required in order to advance toward a sustainable future. Moreover, during economically depressed circumstances, that is Lebanon is passing through since year 1975, only limited financial resources are allocated or spent on environmental recuperation.

- Economic challenges

Issues surrounding the problem of remediation derive from the depressed available mineral prices in general and the abundance of quarries in Lebanon in particular (approximately 7.6 quarry/100 km^2). The tight economic situation also makes it difficult for the industry to invest in cleaner more appropriate technologies, which again, further hinder progress towards a more sustainable mining culture.

- Barriers to regulatory enforcement

The barrier to more sustainable mining in the region is the limited capacity of regulating bodies to carry out their duties. With only a staff of three in the Ministry of Environment, the workload for the concerned office overwhelms the capacity of the available staff. The office is hampered in its ability to carry out many environmental responsibilities, including quarry site inspection.

The limited capacity to carry out the mandate has led to a lack of enforcement of environmental regulations creating a large barrier to sustainability not to mention the problem of overlapping authorities between the Ministry of Environment, Ministry of Interior and Municipalities and other line ministries as mentioned in previous sections.

It appears, however, that economic priorities have weakened the ability of local regulators to carry out their mandated duty. Until a more balanced approach takes the place of the "dependent development path". Local resource managers will remain unable to effect adequate regulation.

- Quarry closure and rehabilitation legislation in Lebanon

One of the main barriers is that Lebanon still lacks the proper technical, financial, administrative and legal framework in respect to quarry rehabilitation and closure legislation and in most cases investors lack instruction and guidance from the government regarding quarry closure and end point criteria for rehabilitation.

- Social inequalities

A large portion of miners is fully occupied with personal things and unable to participate fully in the political process and decision making in the newly democratized country.

- Social, financial and cultural level

The mining policy of most countries as well as in Lebanon, which is enforced by laws and regulations, is usually in language too complex for the artisanal and small scale miners; as is the case in Lebanon, to comprehend. Most of theses miners are not even totally aware of the national laws and regulations in force that affect the mining sector and in some cases inadvertently violate them.

5.4.1.2 Opportunities for sustainability

As is the case in the rest of the world, changes are taking place in government and industry to address environmental impacts of quarry management. These changes can be noted in academic institutions, environmental and labour legislation and regulations as well as changing corporate and civic culture.

- Academic institution

The strongest opportunity for effecting environmental change lies with the academic institutions located in the region. Academic commitment to research in minerals production, environmental management, and social and economic development provides new insights and support projects geared at improving the sustainability of mining practices in the region.

- Environmental legislation and regulation

In spite of a lack of proper regulation and enforcement, the existence of environmental legislation at the government level appears sound. In addition, the strong governmental support for environment creates a good opportunity to improve the regulatory and enforcement systems.

- Changing corporate and civil culture

Another significant opportunity emerging is that some mining companies (very few, in fact just one international company-Holcim) have begun implementing the green agenda in their mining activities as an environmental commitment.

In addition, people are becoming aware of the quarrying problems and consequently are becoming sensitive to the single environmental violations.

- Non-governmental organization

Non governmental organizations are becoming environment driven and more active in Lebanon. This potential opportunity would only lead to the protection of the environment if the concerned NGO is aiming to integrate environment and ecology in their follow up procedure based on environmental criteria. The engagement of active non-governmental organization in the quarry closure legislation and their participation in this process is an added value.

- Government official expertise

The government personnel (and more specifically those of the Ministry of Environment) are very few, but they are highly qualified public servant with different related scientific background enabling them to be an interdisciplinary team and consequently to perform their duties in the most proper way.

5.4.2 Sustainable quarry management practices

The ability to produce construction materials in this era of competing resource needs and values requires new management practices that can maintain efficiency while accommodating the biophysical and socio-economic needs of a sustainable mining community for the present and the future. Poor environmental practices can lead to long term economic expenses for the investor/company, the community or both that might even outstrip immediate benefits, and undermine long-term goals. An investment in cleaner technologies and better practices would increase quarrying efficiency and reduce the quantity of waste, as well reducing waste through recycling.

Policies and plan must anticipate and prevent further environmental degradation, rather than acting after the fact, or in response to *de facto* degradation. Uncertainty should not be used as a reason for delaying preventative measures against possibly serious threats to environmental health (United Nations, 1992; Mitchell, 1997). New mining plans that incorporate the principle of precaution could prevent potentially damaging practices. In addition to protecting the biophysical environment, production costs can be lowered by preventing costly damage that requires clean-up in the future.

Proper management of the natural world is hampered by uncertainty. Human interactions with resources and biophysical environment can be managed by through adaptive policy, planning and management strategies. Adaptive management requires that policy makers, planners, and managers learn from past mistakes and use experience to design new management strategies

(Kay *et al*., 1999). Incorporated into the quarrying industry, adaptability helps to ensure that mistakes are not continued in future construction materials development, ensuring improvement in practices and management over time.

Quarry management practices based on the above principles of sustainability offer an approach that can benefit both the investor and the region where quarrying takes place. It must also be emphasized, however, that there is no single formula. As noted elsewhere "Adaptability, flexibility, responsiveness, and respect for people and the biophysical environment, which we all depend on, are the principles upon which future mines need to be built if there are to follow a more sustainable path" **(**Veiga *et al.*, 2001).

In conclusion, and in order to comply with above mentioned principles of sustainability, efforts from both the public and private sector should be deployed toward approving the soonest possible a mining region in Lebanon or the quarry master plan in consensus with all relevant stakeholders. The quarry master plan should be integrating all relevant scientific criteria and could be based on the research in this thesis as the desk and field surveys as follows:

1) desk survey link all available data sets related to different layers using GIS software (i.e. distances criteria and technical guidelines for each type of investment form MoE database, geology, hydrogeology, urban and residential areas, shrines, land use planning, land cover map, protected areas, hospitals, industrial areas, schools, agricultural areas, etc...);
2) field survey to check all regions deducted from the desk survey in order to determine their suitability for quarrying purposes (access roads, steep degree, land exposition, land shape, weather conditions,…).

In order to approve this plan, it needs from the government side the commitment to environmental priorities and the political determination to approve it, which until now does not exist although several attempts were made with no hope, and from the investor side the compliance with the new regulations and the will to shift their business to the approved areas.

On the other hand the quarry master plan should be practicable and applicable in all Lebanese territories. Foreseeing additional regions in the new proposed amended quarry master plan might have an instrumental effect to provide markets with needed products in a way to overcome disadvantages of the already existing 4 approved regions.

5.4.3 Mine (quarry) closure legislation in Lebanon

Till to date, almost all quarries in Lebanon are in ***progressive operations*** In some cases operations in quarries stop for a while due to several reasons (shortage in products, climatic conditions, product price, change in policies, problem in machinery, lack of workers, etc…) but this do no last forever and quarries restart again operations to regain in a short period all what they *"lost"* in respect of opportunities and products disregarding all types of rehabilitation practices. So a big part of quarries would be called abandoned for a period of time and very few are closed permanently in the proper way where no operations are still ongoing in these sites.

Although the actual quarry decrees state what should be done to rehabilitate new quarries but they never approach the problem of old abandoned not rehabilitated quarries in Lebanon in all respect: legal, institutional, financial and technical.

That is why by setting appropriate foundations, we initially consider the increased importance of integrated quarry planning, including quarry closure, in the light of the sustainable development dialogue as it relates to the mineral resource sector.

An effective environmental plan to close a large quarry should therefore be based on both social and environmental impact assessment. Companies/investors must incorporate environmental and social issues into their strategic thinking and business practices, from exploration through to investment, operation, closure and post closure phases.

Every quarry will ultimately close and the natural resources of the local area will then be used for other purposes. Explicitly recognizing this in the quarry planning and closure process is pivotal. Warhurst and Noronha (2000) note that the benefit of early planning for closure include ensuring that components of the natural environment are available for the future, reducing the extent and expenses of final remediation, reducing future risk of incurring stricter regulation, improving company profile and reputation, and reducing tension and conflict with local communities.

Mine (quarry) closure legislation will ensure that (Hancok and Topurua, 2000)

1. stable and safe conditions are achieved to protect public safety and health;
2. the area is left environmentally benign with no unacceptable or toxic discharges;
3. any remaining infrastructure is sustainable;
4. social sustainability is assured;
5. Future liabilities are minimized for all stakeholders.

The objective of the guidelines would be to encourage the development of comprehensive closure plans including a rehabilitation concept that return all quarry sites to viable, and whenever practicable, self sustaining ecosystems and to ensure that these plans are adequately financed, implemented and monitored within all jurisdiction.

Answers to the following key questions are instrumental for the development of a rehabilitation concept:

1. What do we need for operation, what is the impact and what are the legal requirements?
2. What are the needs of the natural and social environment?
3. Are there business opportunities that contribute to the natural and social environment (biodiversity, social development)?
4. Is there a partnership in rehabilitation and after quarry closure?
5. What are the costs? And how can they best be provided for on closure?

5.5 The selection of quarries for rehabilitation

5.5.1 Problem description

As aforementioned, there are (according to the latest estimate) about 776 quarries in Lebanon that vary in age, shape, type and size.

In principle, the non-active or abandoned quarries that are a hazard to human health and safety, threaten archaeological or historical architecture or sites or decrease those site's appeal, and/or endanger fragile or endangered ecosystems or species (respectively) should be rehabilitated first.

However, the first actuality that inevitably would be realized is that not all of these quarries need actual intervention to rehabilitate and more specifically the non-active or abandoned quarries, which are left for several years without any single operations. This is the case potentially due to some factors, most importantly natural processes that have already acted to reabsorb the quarry sites back into their environment by weathering, erosion processes, natural re-vegetation or other such mechanisms in such a way that would make the outcome look almost acceptable and integral to the surrounding physical Environment in the first place and that the landscape feature present had always been such. In other words, if natural rehabilitation has taken, is taking or will take place effectively is subject to the time frame involved as well the surroundings affected by the quarry. In most respects, these quarries would be considered small in size and in areas relatively remote.

The second actuality to consider in the cost of rehabilitating quarries is that there are cases where cost of rehabilitation could be covered by, and financial gain could even be possibly achieved through the sale of aggregates production. Aggregate quarries are often situated in urban districts in order to lower transportation costs. As a result, many of them have been found trapped within urban borders, especially where rapid urban expansion did not follow a long-term planning, as is the case in Lebanon. The rehabilitation cost in this case could be well compensated by the production of added value resulting from the new land uses. This is often called ***'progressive rehabilitation'*** where rehabilitation occurs sequentially, in a reasonable period of time, while the aggregates are being excavated. With good planning, the

extraction of aggregates proceeds in a logical sequence so that depleted areas can be rehabilitated while extraction continues in other areas of the quarry in order to improve the landscape feature relative to how the quarry was abandoned. *"Planned stripping and replacement of topsoil, subsoil and overburden materials allows the licensee to establish vegetation in as much area as possible, and a start can be made towards developing the site for a particular after use"* (Ministry of Natural Resource, Ontario, Canada). In this case thereby, not only would quarrying be re-allowed on an abandoned site for landscaping reasons (subject to an environmental impact assessment and strict monitoring), yet the sale of these aggregates is a possibility, as are the benefits of reclaiming the land for alternative purposes which achieve economic returns.

The third group of non –active or abandoned quarries consists of those that indisputably need intervention to rehabilitate and thus would require funding. Each site is subject to its own site-specific basis in order to achieve high quality rehabilitation to meet objectives such as (Ministry of Natural Resource, Ontario, Canada);

- The restoration to former use or condition
- Compatibility with surrounding land uses, including aesthetics;
- Agricultural productivity/soil capability; and
- Encouraging biodiversity.

These (the third mentioned category of quarries) are the quarries that would require public (or private) financing sources to rehabilitate, and it is their cost of rehabilitation that should be compared to the cost of environmental damage that they cause. Subject to the severe financial constraints that would undoubtedly be faced, the prioritization of rehabilitating those quarries should be also undertaken.

The economic valuation of the damage costs associated with quarries could be used thereafter in order to prioritize quarry rehabilitation efforts following those hazardous quarries mentioned above. Those quarries that would yield the most return from rehabilitation, returns in the form of improved adjacent land and apartment prices (for example), and/or in the form of improved aesthetics and landscape features should be tackled in such order.

5.5.2 Developing prioritization criteria for quarries rehabilitation

Taken into account the number of non-rehabilitated quarries in Lebanon (Table 29), a prioritization system is necessary to identify those sites that pose the highest threat to the environment and public alike. Twenty criteria and associated parameters were identified and validated of concerned stakeholders. These criteria can be classified into 4 main categories:

1) *Impact* on: (1) land values, (2) water resources, (3) air, (4) ecology, (5) tourist and cultural resources, (6) soil erosion, (7) in-situ pollution, (8) visual impact;
2) *Site Safety*: (9) proximity to sensitive receptors, (10) geologic stability, (11) prone to land or mudslides;

3) *Future Land-use*: (12) surrounding (e.g., agriculture, residential, industrial, etc.), (13) quarry location;
4) *Feasibility*: (14) quarry size, (15) land ownership (public/private), (16) existing rehabilitation activity, (17) potential for natural re-vegetation, (18) clustering conditions, (19) availability of funds, (20) ease of rehabilitation.

5.5.3 Setting-up a Programme for quarries rehabilitation

Based on the Prioritization Criteria for Quarries Rehabilitation a theoretical rehabilitation programme for quarries was developed and few rehabilitation sites were identified (Table 32). In this case only 13 criteria were formulated, whereas from every criteria group some are used. The prioritization system is used to develop a first priority rehabilitation programme to go in line with the current status. Five sites were identified as most pressing quarries to be rehabilitated according to the following criteria:

1. Type of exploitation or quarry type;
2. Environmental and visual impact;
3. Impact on public safety;
4. Proximity to natural resources (water springs, protected areas, wetlands, rivers, etc.);
5. Proximity to residential areas;
6. Availability of an impact assessment study of the site;
7. Land ownership;
8. Geographical location;
9. Willingness of the owner/operator to rehabilitate;
10. Proximity to archaeological/touristic sites;
11. Site location and its effectiveness in acting as a successful rehabilitation model and raising public awareness;
12. Potential after uses (landfill, water reservoir, agricultural land, etc.);
13. Availability of funds or bonds.

Table 32 Rehabilitation sites identified using the prioritization system

Town/Site	District	*Governorate*	Stereographic Coordinates		Criteria
			X	Y	
Msaylha	Batroun	North Lebanon	-319055	14072	1,2,3,4,8,10,11
Sibline	Chouf	Mount Lebanon	- 345205.5	- 56516.5	1,2,4,5,6,7,8,9,11,12,13

Such results would have to be validated and exposed to public and concerned stakeholders before it can be implemented as they may not be compliant with the Ministry of Environment decision's which *a priori* reflects the government political stance/decision concerning quarries rehabilitation in Lebanon.

Rehabilitation has to be planned to the end of life of the quarry in order to demonstrate the technical and financial feasibility of rehabilitation and to define, plan and integrate rehabilitation in the daily quarry rehabilitation.

Rehabilitation planning has to reflect two situations: a) the post closure scenario, which shows the final layout of rehabilitation and the post closure land-use and b) the ongoing rehabilitation during the life of the quarry, which shows the development of rehabilitation and land-use to reach the final stage. To minimize the impact on the environment and to reduce the financial liabilities for the final quarry closure, ongoing rehabilitation is the ideal solution and rehabilitation should be carried out immediately when it feasible.

Rehabilitation projects require planning, and rehabilitation planning is a process. A well rehabilitation planning approach should include the following steps:

1. Situation analysis: define and document all relevant topics for rehabilitation planning such as land use for raw material exploitation, ecosystems, landscape and identify sensitive areas tat might be affected by raw material exploitation;
2. Rehabilitation vision: develop a common vision for future rehabilitation. This vision provides the overall direction for all rehabilitation engagements by the company/investor.
3. Rehabilitation concept: develop a rehabilitation concept that is supported by stakeholders and illustrates how to reintegrate the quarry into the landscape , how to contribute to biodiversity, how the land can be used after quarry closure while respecting the needs of society and to organize the quarry aftercare. The concept may contain several options, ranked according to technical, financial, environmental and social criteria.
4. Rehabilitation plans: plan rehabilitation up to the end of the quarry life in order to define actions and integrate rehabilitation in our daily quarry activities. Rehabilitations plans are necessary to demonstrate the technical and financial feasibility of

rehabilitation to guarantee an efficient quarry operation and to visualize the development of rehabilitation and future land-use in an easy and understanding way.

5.6 Recommendation for sustainable quarry rehabilitation

5.6.1 Proposed technical rehabilitation methodology in Lebanon

The rehabilitation described in this section constitutes an introduction to rehabilitation practices in general by describing the stages involved in the typical rehabilitation process. The objective of rehabilitation works should be at minimum to ensure that depleted quarries are rehabilitated to a condition which

- is safe,
- environmentally stable, and
- compatible with adjoining lands.

While each site is somewhat unique, achievement of this general standard involves sloping embankments and spreading the available overburden and topsoil stripping stockpiles back over the surface.

5.6.2 Planning for Rehabilitation of quarries

Planning stages of rehabilitation are vital for efficiency in rehabilitation works and a sound outcome. The alternatives for end-use post-rehabilitation (see chapter 3.10.7) and rehabilitation considerations or factors described in this part (see chapter 3.10.6), constitute a pillar for rehabilitation planning in terms of decision-making and feasibility assessment.

Rehabilitation planning ideally should consist of the following six steps:

- Information Gathering

It is imperative to have all relevant site information available during planning and decision-making. This will allow the identification of site-specific constraints, and provide the baseline information for the formulation of realistic objectives. It will also enable the selection of an end-use alternative and influence decisions on the most appropriate techniques to use.

Significant relevant information on site specifications will be available from the quarry prioritization activity. Additional data can be gathered through further desk-study or from responsible authorities, local municipalities, and site investigation.

- End-use Assessment

The assessment of post-rehabilitation use can be based on the potential end-uses described in this study, and the desired land use for the site. Often, in order to meet local and regional aspirations, consultation with governmental agencies and the public will be necessary. Rather than being a burden, the target sites can also provide a real opportunity for providing high quality social amenities.

- Feasibility Study

This study constitutes a rough analysis for guidance and decision-making. The benefits of a feasibility study include the assessment of practical and financial viability, the identification of the position of the site in the national and regional planning context, and consideration of possible roles for the site including education, research and public access.

A rough cost analysis or cost estimation or assessment of the potential cost of the various options should be conducted during this stage. In addition, the feasibility of long-term management of the site must be evaluated in terms of responsibility, cost and practicality.

- Consultation

Early and continued consultation in the field or rehabilitation is recommended for guidance throughout the planning phase of a rehabilitation scheme. Specialized agencies and individual experts can be sought for this purpose as preferred by the planning body.

- Project Planning

Sound project planning is essential to safeguard the existing interests of the site and identify appropriate target achievements and restraints. The first stage of detailed project planning is defining objectives, preferably via a prioritized list of objectives, which can act as a guide and ultimately be used to measure the project's success in the future.

Objectives are influenced by the landowner, local authority, community, and/or ecosystem needs, and will relate to nature conservation, amenity, education, research and financial sustainability.

A good project plan should define answer the following 4 issues in a very clear manner:

(1) When to rehabilitate?

(2) How much would it cost to rehabilitate? and is the source of funding known and secure?

(3) Who is qualified to rehabilitate the site? and

(4) What are the rehabilitate steps and methods to be used?

Management Plan Development

A management plan should give precise details for restoration and long term management phases, with the techniques required to achieve the objectives. Restoration operations should be well planned and coordinated, and should also lay out the foundations for long-term funding and aftercare management responsibilities. Ideally, aftercare strategies should be submitted to the planning authorities followed by detailed annual progress reports. Management plans should be monitored and approved by regulatory bodies, including the DGUP and Ministry of Environment.

A management plan of proposed rehabilitation can include among other issues:

1. Projected plan of contours and final levels of site, together with information about replacement depths for soil-making materials, subsoil and topsoil in the form of target restoration profiles;
2. Areas to be restored to agriculture, forestry (types of trees) and amenity uses or for built development;
3. The phasing and time-scale of the working, restoration and aftercare;
4. The methods of filling where appropriate, types of fill and materials proposed;
5. The methods of stripping, transporting and restoring soils; including, where appropriate, schemes for retrieving and utilizing soil making materials, dealing with different soil types and machine movement;
6. Proposed outfalls for drainage of the restored land;
7. Proposed access roads to restored land;
8. Details of proposals for nature conservation enhancement, indicating how they fit with local nature conservation strategies and the biodiversity action plan.

5.6.3 Implementation stage in rehabilitation

Traditional Reclamation

- Preliminary Works & Site Preparation

Site clearing and preliminary preparation is necessary to set up the site for subsequent rehabilitation activities. Vegetation and overburden need to be cleared, while any valuable established vegetation, in or near old or abandoned quarry areas, should be retained where possible. Retaining large trees or vegetation patched stands will preserve centers from which plants and soil micro-organisms can spread into other areas.

In site clearing if present whenever possible, existing topsoil, subsoil, and overburden should be handled separately, since topsoil is more valuable for re-establishing vegetation than subsoil. It is preferable that this phase be performed during non-rainy periods or seasons.

- Groundwork and Re-contouring

This phase applies to the re-shaping of the quarry site and consists of two stages: filling and stabilization.

Filling involves the gradual filling-up of the existing openings and gaps in the site, to achieve desired contours post-restoration. The desired contours should be tailored before and after settlement of the filling material. The site should blend with the surrounding land and off-site contouring, even in cases of water schemes, which should include below water surface contours.

Stabilization should involve the steadying and compaction of filling material and meticulous slope treatment. Landform replication can be used for operational quarries whereby a

simulation is used for quarrying to make it so consistent with surrounding landforms that it requires no further corrections post-operation. This method does not apply to old to abandoned quarries. Restoration blasting is a special form of landform replication where blasting is made in such a way as to give a desired final landscape. Planned blasting can be used for slope correction or for the release of loose rocks, soils, or debris.

Existing steep slopes should be broken down into smaller shorter benches, which would produce a terrace landscape. Alternatively, backfilling of these benches can be done with spoil or soil to produce a moderate hill slope landscape. Although the desired end-use of the site will determine the shape and contouring of the site, the safety and stability of backfill and slopes is an obligation.

- Quarry Re-vegetation

Re-vegetation schemes depend on the desired outcome, be it a natural ecosystem, wetland, orchard, or park. Re-vegetation consists of species selection, seeding, planting and vegetation maintenance or aftercare.

The selection of species to be used on the site will largely depend upon the goals of the project and the site's rehabilitation potential. Adequate plant material, including the right soil type and mount, in addition to organic mater and sufficient nutrients, will need to be made available. Seeding must be done in the right season and conditions such as moisture, etc., to be followed by planting according to the landscaped scheme.

- Aftercare

Aftercare should be seen as an integral part of the working of the site, especially in cases where rehabilitation is conditionally coupled with quarrying operation.

Unless the site is going to be restored to domestic or commercial development, there will be a requirement to return a layer of soil to facilitate vegetative growth. Soil resources should be protected at all stages of restoration, and are a major aspect of aftercare. It is very important to avoid damage to soil structure, since it can be very costly and time consuming to repair. The type and richness of soil will influence the success of re-vegetation, and may jeopardise the restoration scheme particularly where tree establishment or arable crop production is the ultimate aim.

- Alternative Reclamation Method: Use of Bio-solids

This methodology has been mostly found useful in the case of established ecosystems in formerly abandoned or remote quarries. In some cases, the destruction of a thriving ecosystem may not be a good reclamation practice or a cost effective one (Smith and McGuire, 1998).

In some cases, where overburdened areas for over 20 years had a thriving ecosystem where wildlife found food and cover, bio-solids were used as a soil amendment for the stockpile and aglime areas. Bio-solids provided organic content and nutrients for the project's re-vegetation phase, replacing soil removed during mining operations while leaving the existing ecosystem intact.

5.6.4 Recommendations for planning authorities

Legislative and planning authorities usually present recommendations or a set of best rehabilitation practices to suit local needs and standards.

Good rehabilitation practices for quarry planning and rehabilitation indicate for the **planning authorities** and **operators** several aspects they should take into account.

Before the **planning authorities** starts they need a broad consultation also with the operators taking into consideration possible gains for the community as well as the environment. Furthermore it necessary to ensure that plans fit in wider political and regional strategies. Best Rehabilitation Practices can be divided in two categories with different forms for the rehabilitation as follow:

I. Carbonates (limestone, dolomite, marl:

a. Terraces;
b. Re-vegetation;
c. Artistic treatments;
d. Land fills;
e. Playgrounds;
f. Open natural theatres;

II. Sandstone (volcanic ash…)

g. Terraces;
h. Re-vegetation;
i. Land fills;
j. Open water bodies, reservoirs, lakes, etc…,
k. Playgrounds;
l. Open natural theatre;

Types of restoration can also include agriculture, forestry, habitat creation, public open space, specific recreational use, settlements and industrial commercial or, wildlife reserves,

geological sites. The planning authority should observe for gains in the biodiversity of the area and also they should consider the need to agree or specify planning conditions relating to:

- survey of current land use and habitats;
- survey to determine soil classification;
- determination of soil quantities and identify soil making material to make up any shortfall;
- detailed restoration plan;
- detailed aftercare scheme

For the **operator** or contractor for planning of quarry rehabilitation the **Good Rehabilitation Practices** consists from following managing aspects:

1. Reclamation should be treated as a two phase operation:
   - Restoration – infrastructure work, replacement of any or all topsoil, subsoil or soil making material,
   - Aftercare - seeding, planting, fertilizing, watering, draining or otherwise treating the land for a specific end use.
2. Creativity in proposals for restoration is recommended, e.g. combine agriculture with habitat creation or open space.

Consider entering into a partnership with a body which can manage the restoration.

- Phase plans should be drawn showing timed movement of soils and overburden to determine whether progressive restoration is possible.
- Progressive restoration should be done wherever possible to minimise costs and damage to soils.
- Plan work around the proper season.
- Determining the thickness, quality, quantity and relocation of soils allows the correct equipment to be selected.
- Topsoil is essentially a living material that needs to be handled with care, so avoid:
  - putting into dumps needlessly;
  - putting into dump when wet;
  - creating the dumps too deep or wide.

On completion of extraction:

- good quality material which is sandy to assist drainage and bolder free, should be placed on top of the overburden;
- the subsoil should be replaced, followed by the topsoil;
- if no soil available then this will need to be derived from existing material;
- care must be taken to limit traffic on restored horizons;
- all horizons must be rooted and stone picked to promote drainage

Rehabilitation starts during operation and is not something that begins only after extraction is terminated. The general approach that should be adopted is to rehabilitate the exploited areas and allocate them to their end use already during operation. Especially in large quarry areas, where exploitation is executed by zones, land is available for ecological and social projects already during exploitation. Particular biotopes can be "*shifted*" over the whole area during exploitation and preserved. Already exploited area can be fully rehabilitated and allocated to their end use.

When developing a rehabilitation concept, safety and security aspects have to be taken into account (access restrictions, fences, berms, thorn hedges, etc…). Every deposit is unique and the possibilities of rehabilitation depend largely on local conditions (e.g. topography of quarry site, land resources of the company, etc…). At the stage of planning, it is very important to develop only feasible options in order to avoid wrong expectations (e.g. the option of "*full restoration*" is often not realistic due to the lack of suitable material for backfilling).

5.7 Proposed Financing Mechanisms for Quarry Rehabilitation in Lebanon

5.7.1 Abandoned quarries

- Quarries abandoned prior to Decree No. 8803/2002

As mentioned in (see chapter 3.7.6), by definition an abandoned quarry is a site "for which responsible parties cannot be found because they have gone bankrupt, left the jurisdiction, or are unwilling to accept responsibility and, therefore, the government may have to assume the cleanup costs" (Castrilli et al., 2003). The review of international financing mechanisms for funding rehabilitation abandoned quarries (see chapter 3.8) revealed several methodologies, both classical and innovative.

The first and most apparent methodology to finance abandoned quarry rehabilitation in Lebanon is through 'government funded programs from general revenues' or a cost-sharing between national and municipal revenues. However, immediately this conventional methodology would clash with the reality that the Lebanese governments' macroeconomic situation, as outlined in chapter 3.7.6, is in dire condition as most of the expenditures of the Lebanese government are drawn into servicing debt and into salaries, subsidies and transfers (which in the short-medium term is inflexible). This reality trickles down to the municipal level, as many if not most Lebanese municipalities complain of limited funds and financial problems. To add to this constraint is the fact that, as mentioned in chapter 3.9.1, air and water pollution are considered the main environmental priorities to remedy, as revealed by the World Bank report in the cost of environmental degradation in Lebanon.

Nevertheless, the option of funding rehabilitation programs through national revenues or a cost-sharing arrangement between the national and the regional or local levels must remain an option, specifically in emergencies where abandoned quarries are identified to pose risk to

human life or irreversible ecological damage. This must be kept in mind as the Dar Al-Handasah report (1996) indicated that about 71 percent of quarries in Lebanon (since no rehabilitation attempts occurs, this percentage could not of changed much) did not respect the most basic standards and performance criteria (e.g., very steep quarry slopes often exceeding 70º). An estimated 70 percent of the quarries were structurally unstable and 60% were downright dangerous (Dar Al-Handasah study, 1996).

The second potential approach to fund rehabilitation of abandoned quarries is through levies placed on industrial production, or in specific all industries that deal directly with quarry produce (e.g. rock and sand quarry operators). Herein, the Lebanese government could impose a fee or tax (per ton tax) deposited into a dedicated fund earmarked solely for the rehabilitation of abandoned mines (prior to Decree No 8803). This approach is similar to the aggregates levy in the UK which supplies the 'Aggregates Levy Sustainability Fund'. The proceeds of the levy herein would not only go into rehabilitating abandoned mines yet would be used as a tool to encourage the reduction of aggregates usage and their recycling. In essence, this methodology would fit with most of the principles and criteria outlined in chapter 3.8 (polluter/beneficiary pays principles, sustainable development goals, openness, discouragement of future site abandonment and public perception). It would have a negative economic impact however on the Lebanese quarry industry and may be unfair to a few quarry operators (those operators who did not take part in the past legacy of the Lebanese quarrying industry which left over a thousand abandoned and un-rehabilitated quarries). However, these negative economic impacts may be more than alleviated by bettering the image of the Lebanese quarrying industry by having them take (full or partial) responsibility for past actions.

The third potential approach to rehabilitate abandoned quarries in Lebanon is through a government-industry partnership. Herein, the government of Lebanon could commit from its general (or municipal) revenues a part of the rehabilitation costs (calculated to be approximately USD 22 million/year – chapter 3.11) while the quarry industry commits to funding the remaining part. The government-industry approach however would work better as a site-specific endeavour (thereby a short-term and partial solution), unless it is linked to a sustainable and institutional arrangement or program over time.

What is of importance to note here, is that many abandoned sites would have to be reopened for quarrying for rehabilitation (landscaping) purposes, and thereby potential to sell the proceeds from such an operation could cover part, if not whole, of the rehabilitation procedure. In this case, the quarrying industry would initiate rehabilitation completely if the re-sale of the aggregates would more than cover costs of operation (rehabilitation), while an agreement for partial governmental support could be asked for if the resale of aggregates would fall short of the costs of rehabilitating the site. To further insure that rehabilitation would take place on part of the quarry operator, a financial guarantee could be asked to be

placed upfront also to ensure rehabilitation is undergone according to the agreement (and the purpose that quarry operations was re-allowed on the site in the first place). This approach is also similar to the Pennsylvania Department of Environmental Protection (PDEP), Office of Mineral Resources Management approach of 'Government Financed Reclamation Contracts (at little to no cost to the public) and the 'Re-mining Operator's Assistance Program'

The fourth approach could be to create a 'non-profit organization trust fund' that receives contributions from private individuals and companies (or from the central government or a donor agency) for its programs. It is much like a government-industry partnership yet arranged by a non-governmental entity. Companies, governmental entities, individuals (among others) contribute (voluntarily) money with or without having one particular site in mind when they make their contribution. However the applicability of this approach in Lebanon would depend on the ingenuity of the non-governmental organization leading the rehabilitation programs, and its ability or capability of reaching out to attain the necessary funds for rehabilitation.

Finally, a combination of the aforementioned approaches could be undertaken in Lebanon.

5.7.2 Future operation of quarries

For the future operation of quarries, the Lebanese Government already set the ground through Decree No. 8803 (updated partially by Decree 16456). Within Decree 8803, a financial guarantee is required to any would-be quarry operator, the amount of which is set by the NCQ (including the Ministry of Environment). As discussed in chapter 3.11, values for the estimate of financial sureties are shown, yet never were implemented. Chapter 3.8 addresses possible alternative values for quarries. It would be ideal if financial guarantees were adjusted and estimated in the environmental management part of the required Environmental Impact Statement (EIA) of the quarry.

This guarantee come in the form of a letter of credit (issued by a bank that essentially acts as an irrevocable guarantee of payment to a beneficiary), placed in a 'trust fund' that could be created by the National Council of Quarries. These bonds would be returned once the site has been satisfactorily rehabilitated. If rehabilitation is not completed, part or all of the bond amount (or guarantee) may be used to complete the work. The bond amount reflects the expected cost of such work and should be reviewed periodically.

Furthermore, Decree No. 16456 that updates Decree No. 8803 stipulates that no permit for quarrying would be given to a quarry operator if he have failed to rehabilitate to agreed upon standards past quarrying (presumably post Decree No. 8803/2002).

5.7.3 Recommendations for financing mechanisms

In conclusion, remedying the past and evident legacy of Lebanese abandoned quarries and ensuring its prevention in the future is not a complex task to undertake and yet is of substantial importance. Through the selection and **prioritization** of the abandoned quarries which need rehabilitation, those quarries that pose risk on human life due to their unstable nature, and then followed by those that guarantee the highest socioeconomic and environmental returns if/when rehabilitated (e.g. increased property prices and enhanced landscape features) could be rehabilitated first. This would be necessary to begin the momentum (preferably under a comprehensive and time-framed program) to rehabilitate most, if not all, of the abandoned quarries.

With respect to alleviating financial barriers towards such rehabilitation, there are several methodologies that were proposed for the Lebanese context and adopted from international experiences. Some of these proposed methodologies (kindly see section 2.3.9) are already addressed in Decree No. 8803 (updated by Decree No. 16456), while others could potentially add to the Decree, resulting in a more robust and efficient financial mechanism to ensure that the problem of abandoned quarries is solved and prevented in the future.

The industry-government partnership is vital in the context of rehabilitating quarries in Lebanon, as many quarries would need a 'rehabilitation permit' that would require landscaping to occur and offer the removed aggregates (for rehabilitating purposes) for sale. Monitoring however in this case is crucial, to ensure that the agreed upon rehabilitation would take place, and that if a cost-sharing arrangement is in place, the calculated amount of aggregates to be removed is accurate and is serving the purpose of rehabilitation.

On the other hand, an extra levy on aggregate material is recommended to help (partial receipt of this levy would go into rehabilitation) replenish a Rehabilitation Fund (to be set up by the National Council for Quarries) until all abandoned quarries (or those selected for rehabilitation) are rehabilitated. This rate could be kept thereafter (adjusted to include levels of current demand and supply) in order to create incentives for the conservation in the usage of aggregates and to encourage recycling or reuse (pending that price increases are transferred to the consumer). The levy could be an increase of the levy already in place by the Ministry of Finance, and may supplement the annual fees paid by quarry operators to the municipality they are located in.

For current and future quarries, it was recommended that a financial surety (in a form of a bond) be placed upfront before any quarrying is allowed. This surety should be refunded in two stages, as the international review of mechanisms revealed, the first stage upon rehabilitation (75% of total amount) and the second (remaining 25%) two years after rehabilitation attempt is concluded to ensure that the attempt was successful and sustainable.

In essence, it is important to remember always that a financial surety should reflect the real and complete costs of rehabilitation required after the termination of all quarrying activity on a site. From chapter 3.7 however, it is realized that the quarrying industry is subject to a large financial surety requirement (albeit this was perhaps never implemented in the past) which could potentially be a slight obstacle to investments in the quarrying sector in Lebanon. These financial surety estimate divergences can only suggest one necessary approach that should be undertaken. This approach is simply that in order to attain a more accurate idea of the costs involved in quarry rehabilitation, the Ministry of Environment or the NCQ must take on pilot projects (one for each of the various types of quarries) in order to set the guidelines and benchmarks required for quarry rehabilitation (e.g. landscaping, hydro-seeding, and vegetation among other things) in accordance with each type, and more so in order to get an accurate number as to the costs of rehabilitation involved. The latter is vital for any future setting of the financial sureties or bonding that the Ministry of Environment, or other governmental institutions (e.g. Central Bank), insuring companies or financial banks must place or be asked to place respectively. Uncertainty would always persist in this matter as what is being calculated is a future scheme; however, with experience, the correct value for a surety could be a better reflection of reality.

Undergoing such a task is vital to ensure that from the start, the amount requested to be placed upfront (as a general figure and pending further concurring on a case by case basis with an Environmental Impact Assessment) to ensure rehabilitation is the correct amount, that would neither be too large (which would create a disincentive for investment) nor too little (which would fail therefore to successfully rehabilitate an abandoned site). Furthermore, it is common knowledge that many, if not most, of the quarry operators have eluded the payment of a financial surety and eluded taxation of any sort. Thereby, placing an accurate financial surety to reflect the true rehabilitation cost would most likely lower the financial surety required (than that currently in place), increase therefore compliance to this surety (assuming implementation of the law remains as it is) and ensure sustainability of the sector. From this point of view, another important deduction is made being that better implementation of the law, specifically forcing quarry operators to abide by the requirements of a financial surety and strict monitoring or auditing of excavated quantities for taxing purposes is required.

Alternatively, the Government of Lebanon could begin to implement the tax and guarantee levels it has and observe with time the effectiveness (or regressiveness) of the values suggested and how efficient they seem in implementing their objective (taking in mind the economic concerns of quarry operators, of course).

Furthermore, it is recommended that the NCQ set up a quarry rehabilitation office that would monitor quarry rehabilitation attempts, and to ensure that these attempts have been successful or sustainable with the passing of time, and that the levies placed on quarry operations be done, as it is internationally, on a per ton basis to create harmonization of units.

Moreover, the establishment of the National Environment Fund stipulated in Law 444/2002 would provide a practical and effective instrument to support financing of rehabilitation of both abandoned and future quarries. In the case of future quarries, guarantees could be directly placed under such Fund, allowing MoE to directly use the guarantees whenever needed.

Lastly, it is worth mentioning that if the Government of Lebanon had implemented the guarantees, levies and charges it has inscribed (and preferably adjusted them to be more in line with the objectives of rehabilitation), it would have been more than financially capable (also herein pending that the Government experiments with earmarked taxation) of 1) funding a country-wide rehabilitation scheme of most (if not all) abandoned quarries and 2) ensuring that such abandonment would not occur again (guarantees).

5.8 Proposed institutional/administrative procedure for quarry rehabilitation in Lebanon

5.8.1 Problem description

To date, no official/administrative procedure for quarry rehabilitation exists neither at the ministry of Environment nor elsewhere by which owners/operators of old quarry sites (of any type or scale) can be granted a rehabilitation permit or license. Hence, the rehabilitation attempts made by a certain number of companies/operator are due to:

1. They included green agenda into their daily work;
2. monitoring was made by a big consultancy firm;
3. in most cases the consumer was the Lebanese government for project of national interest;
4. the partnership between local companies and international companies which allowed to transfer their know – how and implemented the work in applying the concept and principles rehabilitation;

A draft procedure should be prepared including:

1. Administrative framework: who, how, where and when?
2. Documents (administrative and technical: ID, land ownership, cadastral map, land-use/land planning maps, geographical/survey maps with spot levels, hydro-geological and geophysical assessment reports, EIA reports, etc.) required for application;
3. Technical and environmental conditions of the site (i.e., min. distances from natural resources: springs, rivers, protected areas; residential areas; plot size, etc.);
4. Preliminary evaluation and final approval;
5. Concerned and involved authorities (e.g., municipalities, Mohafez, etc.);
6. Work monitoring and follow-up reports;
7. Financial guarantees or bonds;
8. Eligibility, license duration and renewal;
9. Penalties.

Other procedures such as final approval of work, archiving and systems for operational quarries are routines that already exist and are operational at MoE and other concerned public institution.

However, in order to be effective such a procedure must make part of, or be appended to, an existing or a new legal framework, hence every procedure needs NCQ approval before it can be submitted to CoS and later to CoM for final approval and adoption.

5.8.2 Recommendation for regulation of rehabilitation process

Since no License Request Procedure exists for Quarries Settlement, Regulation and Rehabilitation, therefore establishing and developing a new procedure for this purpose would provide a basic platform to the interested companies /investors in rehabilitating their sites in well concise setup.

Whereas the decree no. 16456 of 02/27/2006 related to the organization of quarries and stone-quarries (amendment decree No. 8803 of 10/04/2002 and its amendments) has tackled in its articles no. 6, 10, 14, 20 and 22, the settlement, regulation and rehabilitation of all kinds of quarries and stone-quarries.

Therefore**,** the mechanism for obtaining a resettlement and rehabilitation license for old quarries – that are un-operational, or non re-exploitable, or un-rehabilitated and that are listed amongst the sites that have been operational prior to the promulgation of the decree No. 8803- must abide by the following mechanism (otherwise, the provisions of the decree No. 8803 of 10/04/2002 and its amendments will apply to them):

1. Will be considered as quarry settlement, regulation and rehabilitation process the series of final adopted procedures for repairing or alleviating the negative impacts of the (current or previous) exploitation process of a site on the surrounding environment in particular and the natural resources in general. The rehabilitation objectives spreads from preventing and stopping sources of pollution, including soil and land stability of the site in a manner securing the public safety, to the restoration of the site to its previous form in sustainable means suitable to its natural surroundings.
2. The application encompassing the documents required by the National Council for Quarries for the quarry regulation and rehabilitation requests shall be presented in a triplicate (one original and two copies) to the *Mohafez* who will forward it to the MoE – National Council for Quarries.
3. The application will be forwarded back to the *Mohafez* with the decision of the MoE – National Council for Quarries, whether it's an approval or a rejection, and this decision will be abiding.
4. The operation timetable will be set according to the technical report information presented by the petitioner and the MoE – National Council for Quarries has the right to impose the suitable timetable for the achievement of the works pursuant to the technical inspection and the information included in the report.
5. The *Mohafez* will issue a licensing decision if the MoE – National Council for Quarries has given its approval that will encompass the timetable, technical and environmental terms that must be included within the quarry regulation and rehabilitation activities issued by the MoE– National Council for Quarries; they are considered as an integral part of the licensing decision.
6. The petitioner will provide periodic reports (prepared by the supervising authority) on the rehabilitation work progress every three months followed by a photographic image to the MoE– National Council for Quarries as well as copies to the concerned municipalities for them to be able to assume their responsibilities of monitoring and following-up the technical work in the field and then report back to the National Council for Quarries their observations, if any, for the appropriate measures to be taken.
7. Any incorrect information could cause the immediate cessation of the work without any acquired rights to the petitioner.
8. The operation fees stipulated in article 7 of the decree no. 16456 of 02/27/2006 will be defined by a decision of the finance minister upon a proposal of the MoE.
9. The amount of the bank guarantee stipulated in article 7 of the decree no. 16456 of 02/27/2006 will be defined by a decision of the minister of environment
10. When the rehabilitation works are finally concluded or stopped, the petitioner must report the termination of works by a letter addressed to the *Mohafez* who will in turn forward it to the National Council for Quarries for the monitoring of the rehabilitation works and adoption of the appropriate decision. The notification will be Appendixed by a statement with all the information regarding the achieved rehabilitation and

regulation works according to the imposed implementation phases and the measures adopted to avert threats.

11. Once the termination of the operations acknowledged, the *Mohafez* must, by one-self or upon the proposal of the National Council for Quarries, consecutively inform the petitioner of the works that he still considers necessary for the execution of the rehabilitation and protection process. Once it has been verified that all the required operations have been achieved, the *Mohafez* will issue, upon the proposal of the council, a decision regarding the termination of the operations, closure of the quarry and reimbursement of the guarantee imposed upon the petitioner after deduction of the due fees pursuant to its objective. The work termination decision will be reported to the ministry of interior and municipalities, the ministry of environment and the National Council for Quarries.
12. If the petitioner did not fulfil the engagements and operations that were incumbent to him during or upon the termination of the rehabilitation process, the National Council for Quarries can then execute them at the petitioner discretion. The amount will be taken from the original guarantee deposited, if the amount is insufficient, the petitioner will still be under obligation to cover the difference; these provisions will also be applied in case of license cancellation, expiry or waiver.

5.8.3 Required documents

First: Organizational Documents

- Identification documents (copy of the ID/ or proxy)
- A full cadastral map + a statement of the property approximate areas
- Delineation and servitude statement not exceeding one month from the application submission date;
- Property attestation and realty attestation of fact of the un-surveyed areas non exceeding one month from the application submission date;
- Commitment of good operation practices, a waiver at the notary public to refrain from undertaking any extraction work once the National Council and Mohafez have approved the termination of the rehabilitation works;
- Rental or exploitation contract or other;
- Supervision agreement contract signed by an experienced civil engineer, agronomist, geo-mechanic or geologist experienced in work discharging;
- A map of the land location current status + longitudinal and latitudinal sections;
- Topographic map at (1/20000) scale showing the property location and relation with the surrounding environment;

Second: Technical Maps and Documents

- detailed rehabilitation maps with longitudinal and latitudinal sections and explanatory graphs;
- Timetable of the execution of the work phases;
- Comprehensive digital panoramic photographs of the location dated and signed by the pertinent party.
- A tentative statement of the digging/rubble quantities and the estimated surplus, their accumulation, transfer and handling procedures, submitted by a sworn and certified topographer registered at the topographers syndicate or a topographical engineer properly registered at one of the two engineers syndicate;

Third: reports

- An environmental status report including:
    - An environmental description of the site with at least a 1500 m width from each side that includes the natural balances, archeological sites and the surrounding land use in accordance with the comprehensive directives of the Lebanese territories or in accordance with any directive specific to the area encompassing the site;
    - Direct or indirect environmental impact assessment such as air and water pollution and their resulting damages to health, vegetation destruction, noise, damages from the means of transportation, infrastructure damages etc, and proposing solutions to mitigate these damages.

- A comprehensive and detailed rehabilitation report including:
    - The final use of the site with mention of its content after the rehabilitation;
    - Rehabilitation plan of action and timetable;
    - The final site status after the achievement of the rehabilitation process.

Fourth: The Municipality Council Decision

The municipality council decision/or the district commissioner decision where there are no municipalities (objections and complaints will be Appendixed to the municipality council decision in case of a disapproval provided that the latter is justified within the legal time limits)

5.8.4 General environmental and technical terms

1) It is absolutely forbidden to cut fruit, gum or pine trees.
2) No transfer of agricultural soil or rocks; or rubble outside the real estate or use only for the land regulation and rehabilitation prior to the approval of the MoE- National Council for Quarries of the work execution, for the excess quantities only;
3) Taking into consideration the guidelines of the MoE and/or ministry of agriculture and all the measures observed for the preservation and use of coverage soil;
4) keeping an equivalent of 10% of the total area for rehabilitation for the improvement and development of the existing and new ecological systems that has or could appear within new environmental conditions and time;
5) Preserving the rights of others, no trespassing on public properties and achieving the work within the deadlines;
6) Permit use only for the purpose approved by the MoE- National Council for Quarries under penalty of the immediate cessation of work;
7) Fencing the property with bushes or gum trees and keeping the current tree fence.
8) Creating a soil or green vegetation cover to mitigate the visual and sound pollution, and dust from the rehabilitation operations;
9) No use of explosives will be allowed prior to the approval of the MoE - National Council for Quarries and the pertinent authorities with a written commitment in this regard;
10) No crusher of any kind or size will be installed for the production of gravel prior to the approval of the MoE - National Council for Quarries;
11) Submitting a performance bond which value will be defined by the National Council for Quarries pursuant to the type and form of operation;
12) Operation fees and duties will be paid upon the promulgation of the licensing decision to the pertinent municipal fund or to the treasury outside the municipality;
13) The National Council for Quarries retains the right to impose new environmental terms when needed, to perform periodic monitoring; and the right to request the suspension of the license if the required environmental terms are not being implemented without any acquired rights to the concerned party;
14) The approval will be deemed expired 6 months from its date of issuance by the MoE-National Council for Quarries (the *Mohafez* must justify the non-promulgation of the decision if so).

5.8.5 Recommendation for quarry closure and rehabilitation in Lebanon

The complexity of social, cultural and economic issues in Lebanon today complicates the process of physical decommissioning and rehabilitation of areas disturbed by quarrying. Before the enactment of the new legislations (decrees No: 8803 and 16456) there was no comprehensive law or regulation that dealt adequately with the wide range of issues relevant to quarry closure. In order to remedy this deficiency in time for closure of all abandoned non-rehabilitated quarries, the government of Lebanon should initiate a process to develop such a policy. Its aim is to establish a comprehensive law for the implementation of the quarries closure

One of the major issues raised during the public consultation (with the Ministry of Environment personnel) on the legal framework for quarries in Lebanon, and which gained large consensus, was the lack of reinforcement of existing legislation, the conflict of mandates among the various concerned authorities and the political interferences. It should be noted that hitherto all environmental regulations pertaining to quarries took the form of either a ministerial decision or a decree which can easily subjected to political contentions. Given that, and based on the results analysis of existing legislations, a new comprehensive ***law*** for regulating quarrying sector including the rehabilitation component should be drafted and reviewed before being submitted to Council of State (CoS) for verification and later on to CoM then parliament for final approval.

The new proposed law should stop once and for all the overlapping of authorities and consequently stop the issuance of the called “administrative extensions” and furthermore stipulate that quarry investors or operators to produce quarry closure and rehabilitation plans for review and approval well before closure. Following the acceptance of the closure plan from the responsible authority, quarrying companies should report progress at regular intervals. Plans should address both social and physical aspects of quarry closure and quarrying companies are required to provide financial guarantees for proposed closure work. The law should also specify technical guidelines for the minimum acceptable specific requirements (actions and targets) of a quarry closure plan. Ultimately a successful quarry closure plan is by far a technical, social and financial exercise.

The law will ensure stakeholder input in the quarry closure process. It seeks to facilitate the transition of a local economy from mineral dependence to post quarrying economic development in other areas. While it does not define the exact nature and extent of stakeholder input into quarry closure planning, the sensitive management of stakeholder input and expectations will play an important role in its implementation.

The proposed law should address all the above mentioned mechanisms (technical, financial and institutional/administrative) and integrate them in one set-up. A national debate should take place at the early stages and all involved stakeholders should be part of the proposed law

before its promulgation in a voluntary and consultative/explanatory programme appraisal. It is worth mentioning that the proposed law should complement at first what the actual decrees already tackled in terms of rehabilitation and organization and afterwards adjoins all items and articles related to rehabilitation and quarry closure plan (.e.g. rehabilitation concept, procedures for rehabilitation, rehabilitation of abandoned quarries, the effect of non-rehabilitation on new licenses).

In addition to what is mentioned, it is worth pointing out that the new law should tackle the new and advanced technologies related to the quarry sector as well as other type of investment that are until to date not well conceived in Lebanon such as the issue of open pit particularly for the cement quarries that require a huge areas to excavate large quantities of needed mineral from hillsides and mountains. These mountains and hillside would disappear in few years.

The objective of the proposed law guidelines is to encourage the development of comprehensive closure plans that returns all mine sites to viable, and whenever practicable, self-sustaining ecosystems, and to ensure that these plans are adequately financed, implemented and monitored within all jurisdiction.

A fully integrated mine plan, including rehabilitation and closure details, is a key aspect to the sustainable development practices. Successful closure will assist in passing on resources and basic infrastructure, which members of local communities can use to generate sustainable economic activity.

Once the law is promulgated, it is recommended to organize a training and skills development at the national level for the investors, operators/companies. The emphasis would be on practical ("hands-on") instruction with limited technical jargon, with the aim of providing sufficient practical experience and know how to be able to run the mining operations safely and economically in compliance with pertinent mining and environmental laws.

Objectives and principles of quarry rehabilitation and closure guidelines

Six key aspects with correspondent objectives and principles determine the quarry rehabilitation process and closure guidelines. This set-up should figure in the proposed legal framework for quarry (mine) closure and rehabilitation in Lebanon. In essence, the proposed law should address mainly the following aspects:

1) Stakeholder involvement,
2) Planning,
3) Financial provision,
4) Implementation,
5) Standards,
6) Relinquishment.

Consequently, each company/investor should abide by these objectives and principles while planning their rehabilitation scheme for their quarry. Figure 13 describes the conceptual model to be adopted for quarry rehabilitation all a long the different steps that should be tackled to really undertake the rehabilitation scheme for every quarry site

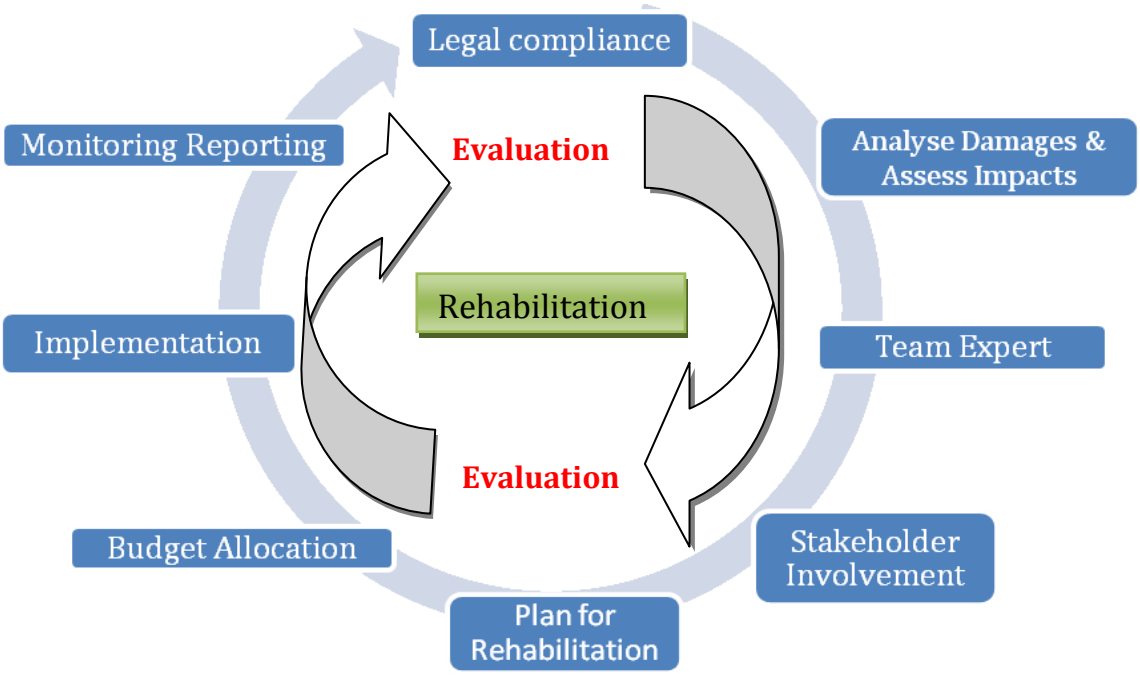


Figure 13 Conceptual Model for quarry rehabilitation

6. PILOT PROJECT AS CASE STUDY ON THE REHABILITATION OF SIBLINE QUARRY SITE

6.1 Arguments for the case study

In Lebanon as in most developing countries, disposal of municipal solid waste has been a major problem, particularly in areas where there are high population densities, high production of waste and scarcity of land adequate for landfill. Under such conditions, uncontrolled waste dumping along the seashore has been an unfortunate yet common practice for solid waste disposal in major urban centers; such was the case of the Normandy landfill for more than 15 years. This site forms literally the sea façade of Beirut central district and was created as a result of haphazard dumping of municipal and other waste generated during the 15 years of civil unrest (1975-1990) (Fig. 14).

On another note, the study outcomes in chapter V showed that the biggest percentage of the operational and abandoned quarries in Lebanon is not properly rehabilitated and only, very few are partially rehabilitated which figures, among others, Sibline quarry.

The government of Lebanon initiated a rehabilitation process to a part of Sibline quarry as a response to the arising need of shifting the Normandy landfill to another place more suitable and environmentally sound. The implementation of this operation was the outcome of a public – private partnership including the government of Lebanon institutions from the public sector (CDR, MOE,) and the contractor, designer, landowner and laboratories from the public sector. It is to be noted that the financial charges needed to conduct the rehabilitation operation were part from the government of Lebanon commitment towards promoting a sustainable natural resources management plan in Lebanon.

It was a big challenge to test the theoretical approaches of the research done in frame of this thesis in practise accompanying the planning and realisation of the Sibline quarry case study.

Based on the descripted methods of rehabilitation management the rehabilitation of the Sibline quarry will be realised by backfilling it with the leftover inert materials transferred from the Normandy landfill as detailed in sections below. This proposal presents a double benefit at the environmental level since it brings up solutions for the two main major environmental problems in Lebanon.

6.2 Aim and research design

The aim of the case study is to envisage a rehabilitation scheme for quarries in Lebanon and to address a sustainable procedure for natural resources management.

The purpose of the case study is to examine how the introduction of a “quarry rehabilitation process” based on a stakeholder partnership can be effective in controlling Municipal Solid Waste (MSW) over-generation in the area Beirut central district. The paper adopts the DPSIR framework as a strategic management approach, (see chapter 4.2.2) to analyse the causality

behind quarry rehabilitation problem by passing through the complicated interaction among various stakeholders involved in the overall rehabilitation management system at the national level.

6.3 Detailed objectives of the case study

- To carry out rehabilitation on a part of the Sibline quarry site (≈15.000 m^2) aiming at enhancing the overall vegetation in the quarry area and will improve the overall integration of the said quarry or part of it with its surrounding;
- To transfer the leftover inert material from the Normandy Landfill towards the non-operational Sibline quarry site and properly landfill them with the ultimate goal of quarry site rehabilitation. After compaction a maximum total quantity of inert material mixed with soil is expected to reach ≈ 85.000 m^3

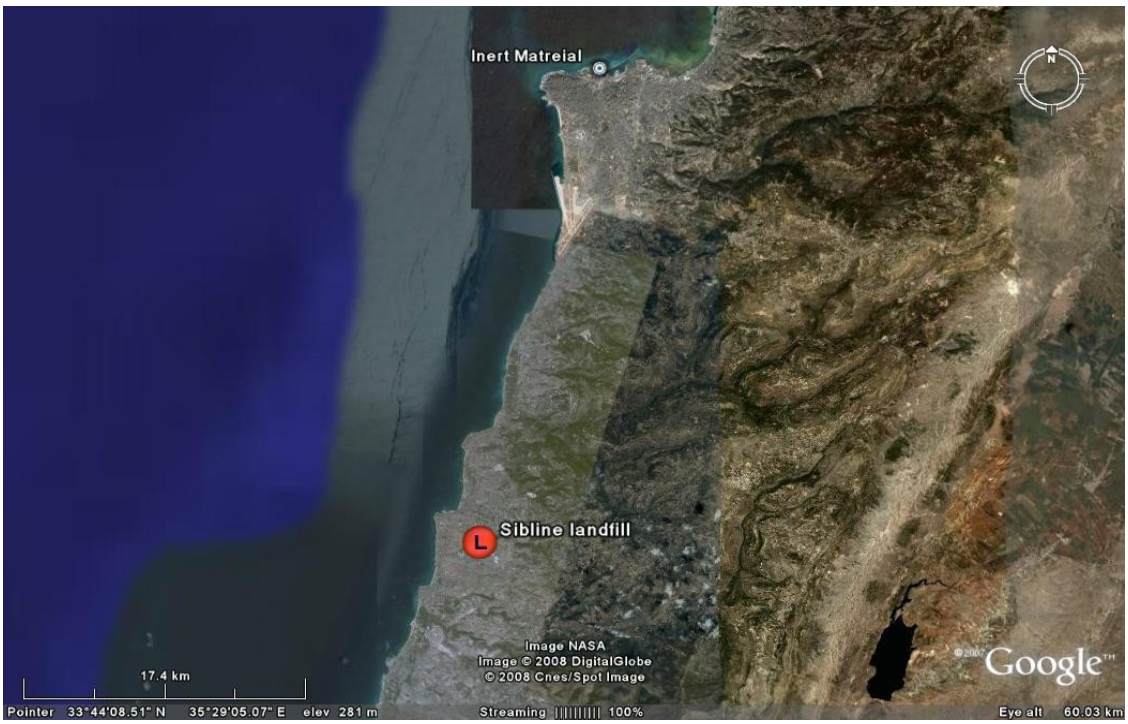


Figure 14 Satellite image showing the Normandy Landfill and the Sibline quarry (Google Earth Satellite image)

6.3.1 Project description and details

Project time frame: 7 months in between years 2007and 2008

Concerned parties in project implementation:

Client: SOLIDER-CDR Council for Development and Reconstruction;

Land owner: private property belonging to Jumblat Family;

Contractor: Arab and Co. enterprises;

Designer: Rafik El-Khoury and partners (Consulting-Engineers);

Consultant: Ministry of Environment;

Laboratory: American University of Beirut (AUB) Core laboratory;

Targeted groups: Citizens of Beirut and Chouf areas as well as Chouf municipalities grouping.

6.3.2 The selection of Sibline Quarry

The Sibline quarry site can be considered as a pilot case for quarry rehabilitation in Lebanon due to the following characteristics:

- Close to the high way (≈2.8km) and to
- Beirut the Capital of Lebanon (≈ 35 km);
- situated in relatively small catchment's
- basin not reaching nearby rivers;
- One of the very few partial rehabilitated quarries in Lebanon (complete terracing as shown in the Fig. 15);
- Low elevation (highest point in the quarry ≈220m) which means less impacts on water resources and reservoirs
- Close to the Landfill site which means less travel time and consequently less transport cost and less air pollution, and nuisance (Fig. 15);

Fig. 15: View on the Sibline quarry

- Laboratory test results showed that the leftover inert material is composed of soil and rejected inert material consisting mainly of plastics and fabrics.
- Moreover, the test results indicated also that the inert material is not contaminated with chemicals, heavy metals and hazardous waste.

6.3.3 Reason for selecting the Sibline quarry as dumping

Double benefit by conducting the most flexible solution that correspond to the better environmental practice in the Lebanese context:

- Remove leftover inert material from the sea shore and reclaim the land for further utilities;
- Rehabilitate and closure plan for a part of Sibline quarry (Figure 16) left without final rehabilitation phases.

Figure 16 Satellite image of the Sibline quarry (Google Earth- Satellite image)

6.4 Conceptualizing a quarry rehabilitation using a DPSIR framework

The methodological approach of this research project is briefly described in Figure 12. However an independent analysis is done for each of the two study components: the landfill and the quarry (Figure 17 and 18).

Environmental phenomena often overlap various spatial levels (Grainger *et al*., 2004)**.** A number of variables (some of them are inter-related) can be found to be positively correlated between rehabilitating a quarry and relocating a landfill. Therefore, numerous DPSIR frameworks can be used at different levels of the defined problem with a number of driving forces specified. However, due to the space limit, this paper will only focus on the economic growth and the sustainable development as one key driving force for the quarry rehabilitation case study.

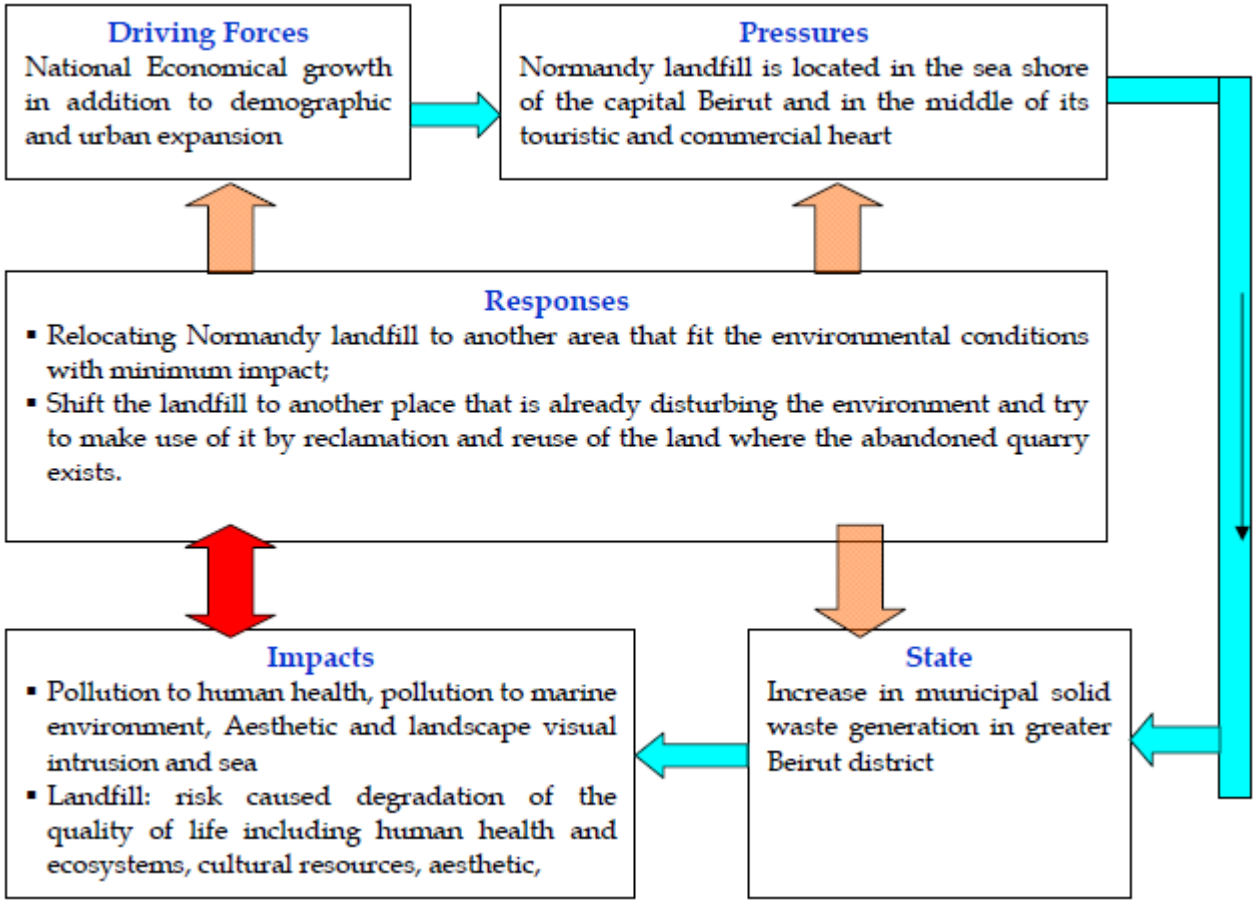


Figure 17 DPSIR scheme for the Normandy landfill

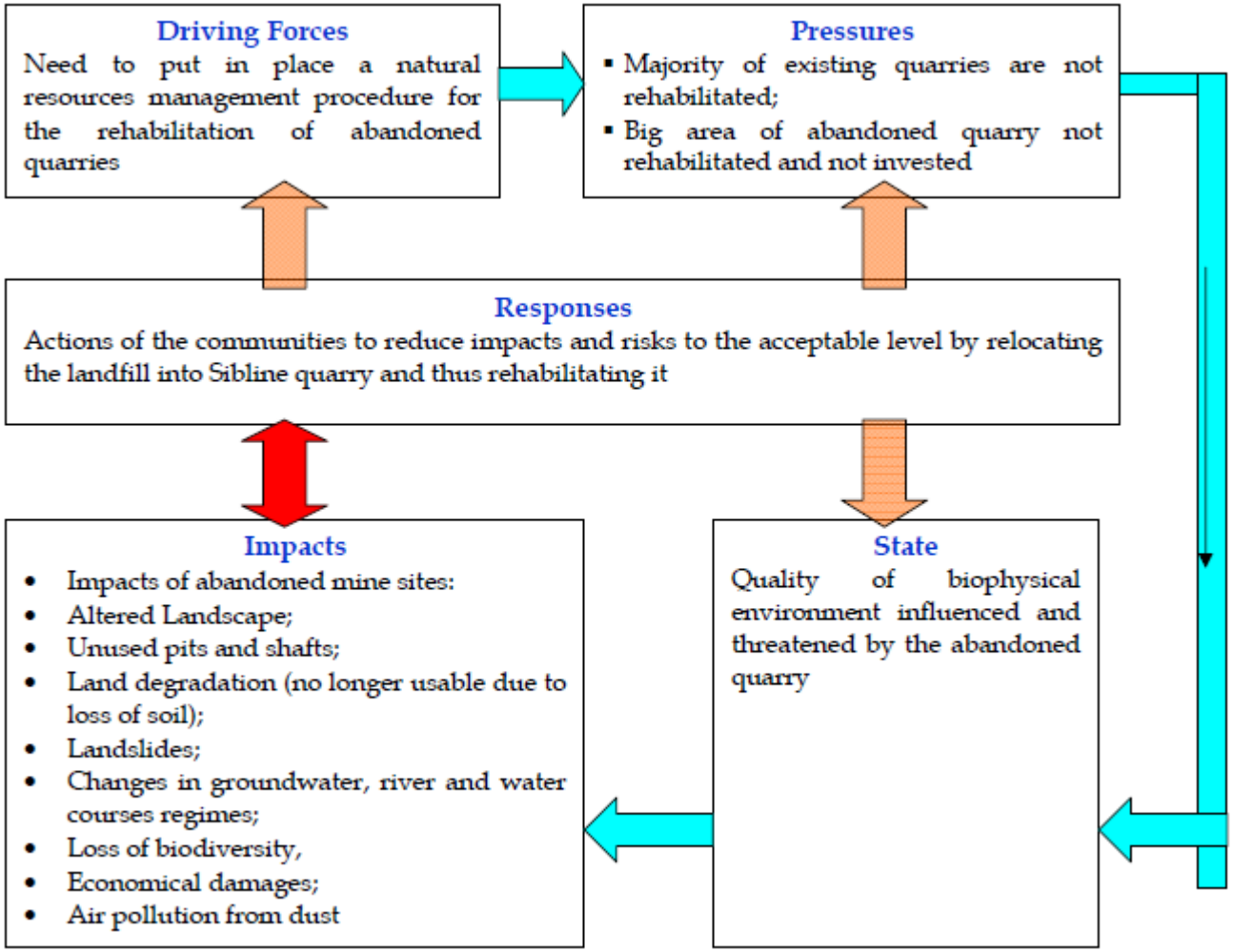


Figure 18 DPSIR scheme for the quarry rehabilitation

6.5 Rehabilitation of Sibline Quarry case study

6.5.1 Normandy Landfill

Situated at the Northern Coast of the capital Beirut, the Normandy Landfill was for more than 15 years a result of uncontrolled waste dumping along the seashore and formed, until recently, literally the sea façade of the Beirut Central district. The material consists of demolition material, bricks, timber plastic, glass and soil. Fig.19 shows the inert material at the Normandy Landfill before transfer operations.

Figure 19 Satellite image of Normandy Landfill in Beirut central district (Google Earth)

6.5.2 Sibline Quarry – topographical data

The Sibline rock quarry is located in the Chouf region in the plot number 25 of the Sibline cadastral area covering a surface area of approximately 890.000 m^2 (CDR-NPMPLT 2004). The quarry commenced its quarrying activities in 1993-1994 and was licensed by the Council of Ministers decision to supply over 5 years the rocks needed for the extension of the Beirut International Airport (BIA) that took place from 1994 to 1998. Approximately 16 million tons of rocks were transferred from the Sibline quarry to the Beirut International Airport (BIA) in the Ouzai area. At later stages of the quarrying course, the Ministry of Environment was part of the follow-up process from 1996 until the end of the quarrying activities.

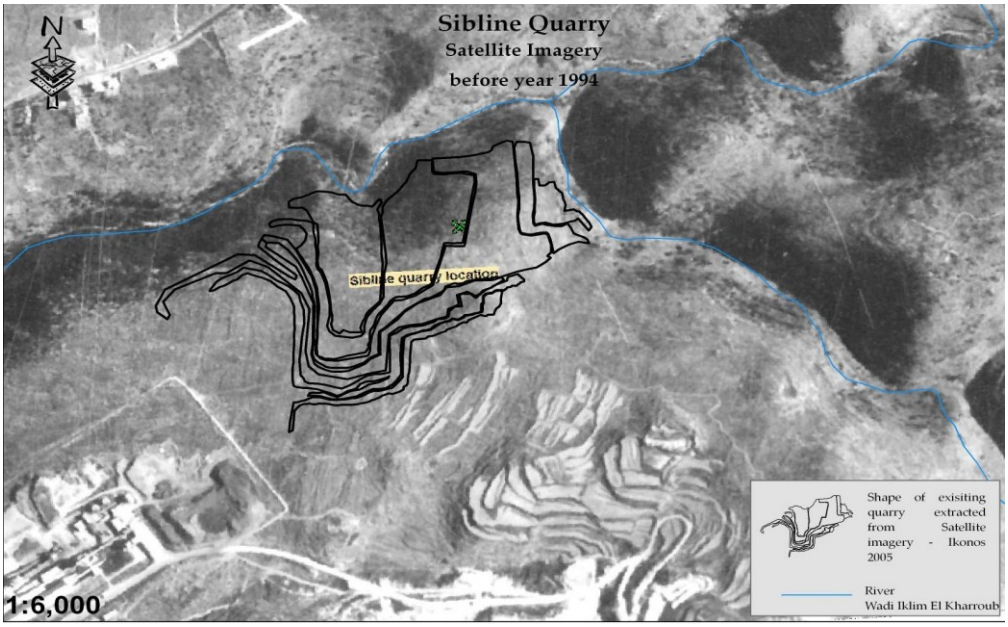


Figure 20 Satellite image of the Sibline quarry before excavation –year 1994 and the digitized layer of current status

HOCHTEIF-CCC joint venture was the contracting company who operated the quarry during excavation. At the end, the land was left with six main uncultivated terraces and two sub terraces at the North East side of the quarry to ensure land stability and esthetic considerations (Figure 20). The Sibline quarry consists from the 6 Berm levels and the corresponding topographical data (Table 33).

Table 33 Topographical data of Sibline quarry

Berme[1]	≈ Elevation (m)	≈ Area (sq m)	≈ Perimeter (m)
A	129	24511.8	779,26
B	146	35621.21	1665.75
C	163	34202.52	2084.87
D	180	14759.23	2020.47
E	197	12415.95	2023.72
F	214	6104.35	1072.51

[1] mound of earth placed at the base of a wall

By using the satellite imagery (Ikonos 2005) it was possible to digitize the quarry in its actual shape and furthermore to overlap, using Arc GIS, different layers of significant relevance to have a clear understanding of the situation as shown in Fig. 21

6.5.3 Sibline quarry environmental baseline data

A detailed survey was carried out to assess the different base line data of all the environmental aspects i.e. location, climate, geology, hydrogeology, surface water ground

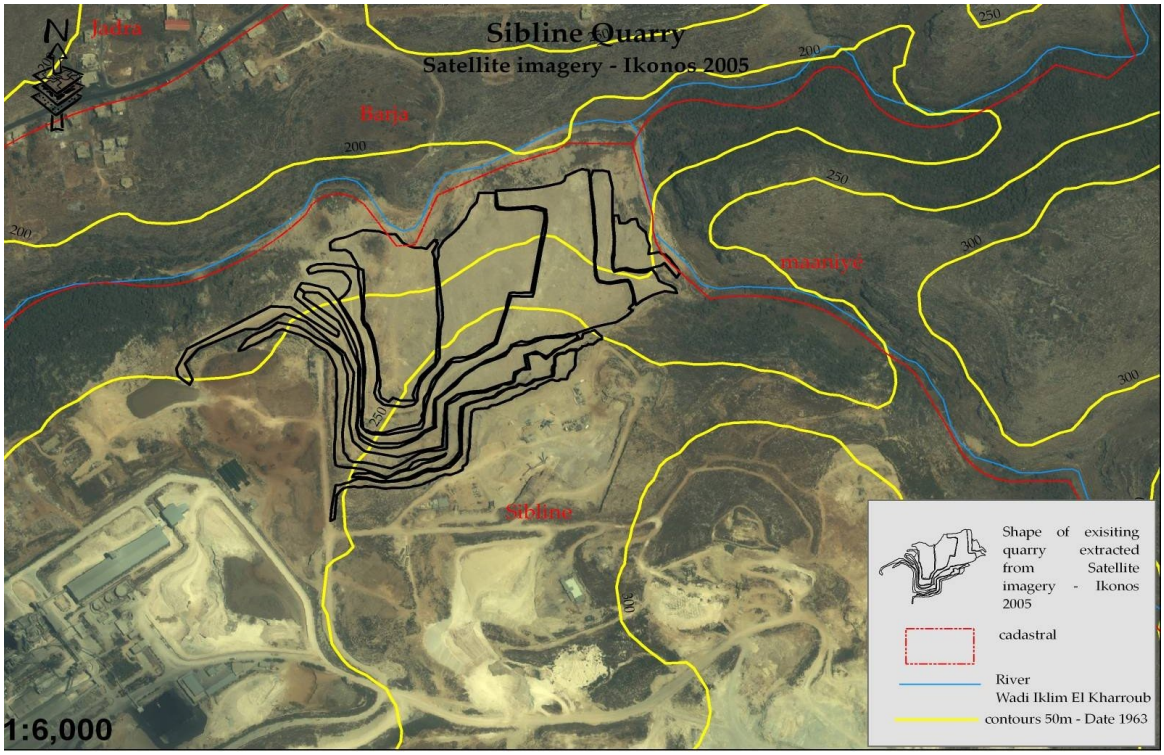


Figure 21 Overlaying the existing quarry after digitizing on the new satellite image (Ikonos 2005)

water and surface water quality, ambient air quality and noise level, topography, biological environment, socio-economic environment, characterization of leftover Inert material.

For relevance purposes to the study case, only location, topography, biological environment, socio-economic environment are briefed as below:

- Sibline quarry site Location

It is situated approximately 2.8 km east of the Mediterranean coastal area, and several villages are situated nearby the quarry site as shown in table 34 and Fig. 22.

Table 34 Sibline quarry site location

Village name	Direction with respect to Sibline quarry	≈ Distance from Sibline quarry
Sibline	South	1.3 km
Barja	North	1.6 km
Chehim	East	2.8 km
Jadra	West	800 m
Delhoun	East	2.04 km
Ketermaya	South East	1.9 km

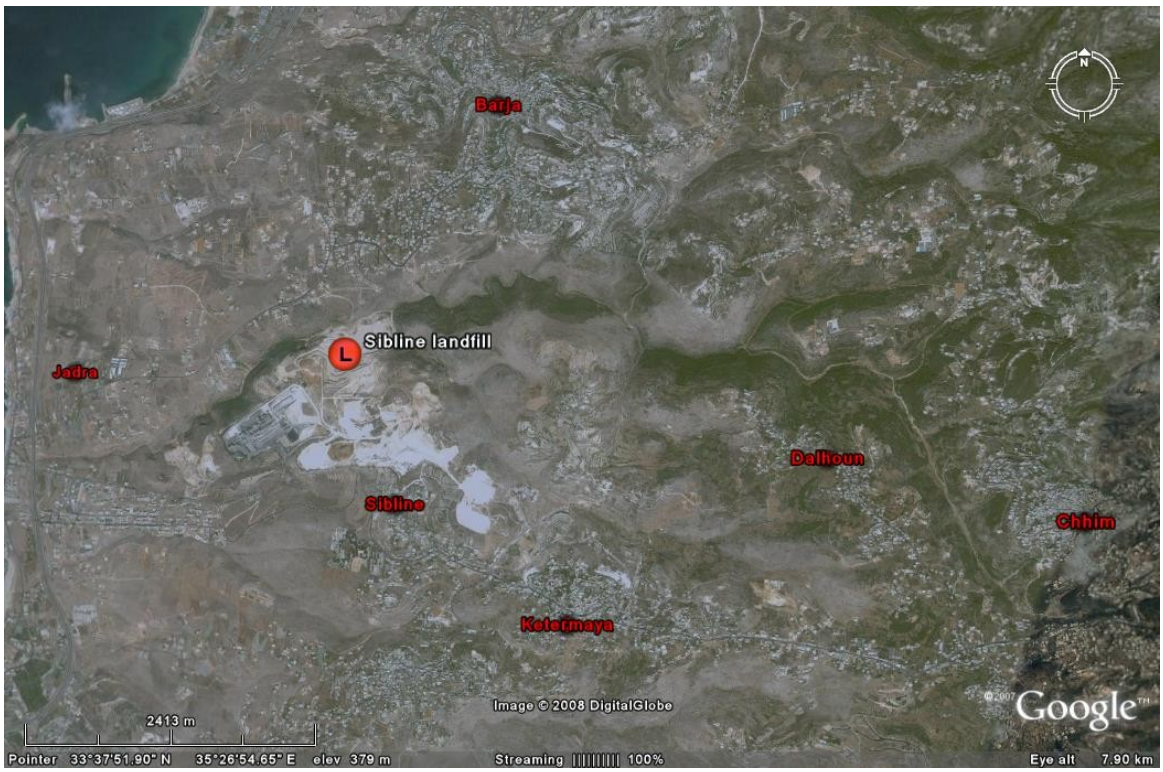


Figure 22 Satellite image of the surrounding villages to the Sibline quarry (Google Earth)

The area surrounding the quarry consists of mainly industrial and commercial areas on the southwest and west sides and mainly residential areas on the north, east and southeast sides.

- Topography

The altitude of the proposed rehabilitation site ranges between approximately 130m and 220m above sea level. The area where rehabilitation is actually proposed is a relatively flat piece of land. The surrounding steep slopes of the proposed rehabilitation plot were produced during the excavation of the quarry in its operation period.

- Biological Environment

The facility site falls in the Thermo Mediterranean vegetation level on limestone substratum (vegetation growing on altitude from 0 to 500 meters - refer to vegetation zone Fig. 25) (Abi saleh and Safi, 1998)**.** In reference to Corine Biotope Classification (Bissardon, M., et Guibal, L., 1991), the proposed site for rehabilitation can be classified under section 84.412 corresponding to quarries for crushed stone (Abi saleh and Safi, 1998)**.**

On site vegetation cover is limited to scattered presence of opportunistic species mainly concentrated on abandoned quarry embankments and rock fractures. Those species are either annuals or common species of degraded areas such as *Inula visoca*, *Callycotom villosa*, *Geranium distachyus, Micromeria nervosa, Phagnalon rupestre, Sarcopoterium spinosum* and *Hymenocarpus circinatus*. On several regions in Lebanon there are degraded quarries were such species are available (Figure 23).

Figure 23 Opportunistic species recognized in the degraded quarry habitat

Surrounding vegetation cover is severely degraded primarily due to recurrent overgrazing activities over time and is mainly represented by scattered tree species such as *Ceratonia siliqua, Quercus calliprinos, Pinus brutia and Pistacia terebinthus* and low vegetation cover with presence of *Cistus creticus, Asparagus acutifolius, Salviatriloba, Sarcopoterium spinosu, and Spartium junceum* as shown in Fig. 24.

Regarding the site's land use/land cover (CDR-NPMPLT, 2004), the site is located in a river valley where the dominant land cover features consist of:

- Industrial/commercial area southeast of the site;
- Industrial facilities (Sibline Cement Factory to the west and Jieh thermal power plant to northwest of the site);
- The urbanized town of Sibline to the south of the site;
- Dense oak forest southwest and northeast of the site;
- Medium-dense grasslands south of the site;
- Few agricultural fields of crop plants west of the site;
- Olive orchards East of the site.

Figure 24 Scattered low vegetation existing in the surrounding and nearby environment to the Sibline quarry

As mentioned above and in reference to Fig. 24 on Sibline Land-Use Land-Cover map – MoE, UNDP- 2002 immediate surroundings of the quarry consist mainly of commercial/industrial areas to the southwest and west of the quarry and mainly residential areas to the north, east and southeast of the quarry. As can be seen in the land cover map below, there are vegetative areas along the path of the Ouadi Iklim El Kharnoub to the east and west of the quarry site.

The Fig. 25 shows the investment of the Sibline quarry affected originally the land cover already existing at the beginning before the start up of the excavation operation that took place in year 1994. In reference to the above-mentioned land use land cover map and the comparison with the original land before excavation as shown in Fig. 18, the operation of the quarry degraded approximately an area amounting to 34.485 m^2 of *"Végétation arbustive avec arbres dispersés"* as classified in the Land-Use Land-Cover Map – MoE,- 2002. (MoE-Land use land cover Map, 1:20.000, 2002

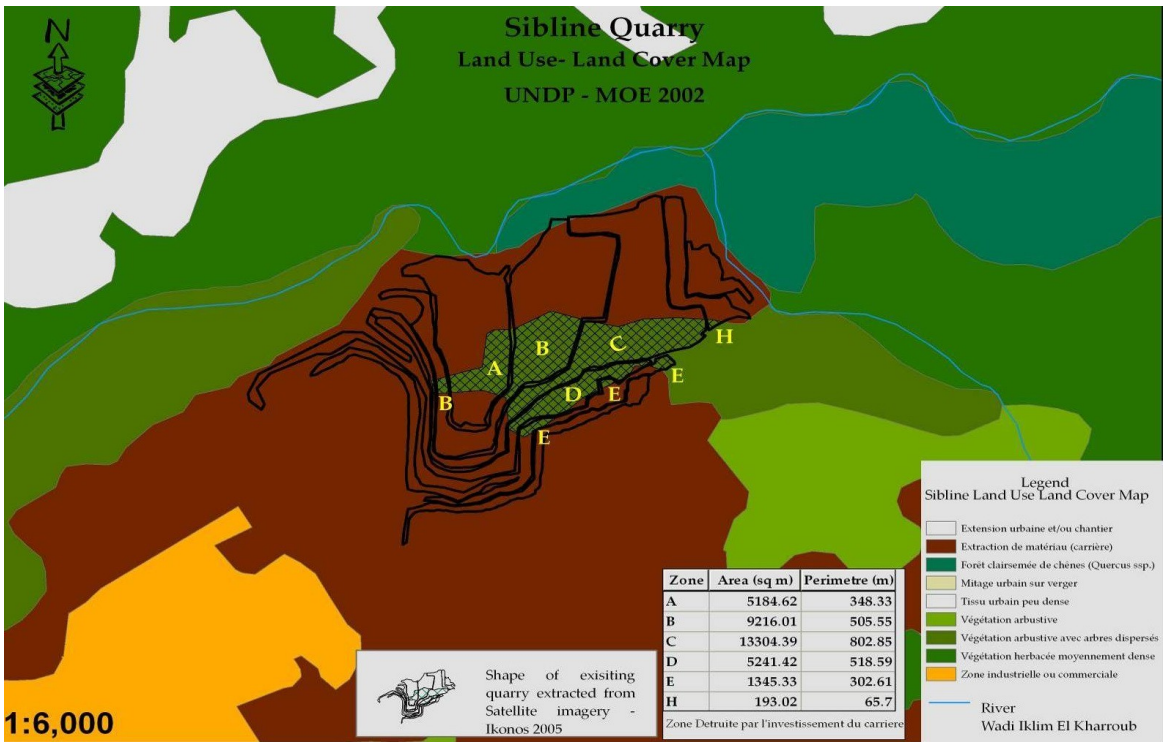


Figure 25 Sibline Land-Use Land-Cover Map (MoE, 2002)

Following the Sibline Land-Use Land-Cover map – MoE, UNDP- 2002 (Figure 25) immediate surroundings of the quarry consist mainly of commercial/industrial areas to the southwest and west of the quarry and mainly residential areas to the north, east and southeast of the quarry. As can be seen in the land cover map below, there are vegetative areas along the path of the Ouadi Iklim El Kharnoub to the east and west of the quarry site.

- Socio-economic environment

The main activities within the Chouf and Eqlim El Kharoub area include agricultural (23%), industry (27%), retail and tourism. In respect to industrial activity, there are two main industries in the area namely the Jieh Thermal Power Plant and the Sibline Cement Factory that hire a significant number of employees from the local population. As for the tourism, there are many appealing resorts and restaurants in the area attracting a significant number of tourists and city dwellers therefore placing this area as a major touristic attraction. The different working categories in the region include: professionals, immediate professionals, government employees, agricultural workers, skilful workers (technicians) and regular uneducated employees. Approximately, 19% of the residents are within the low-income bracket, about 50% have medium income and about 31% are above the medium income bracket (MOSA, 2001).

6.6 Description of the rehabilitation process-Case Sibline Quarry site

After identifying the baseline data of the quarry and assessing the impacts of the rehabilitation process, a rehabilitation operation was made on the level A of the Sibline quarry as referenced in Figure 26.

- The Rehabilitation process

Generally, restoring a limestone quarry site could be conducted in several ways:

1. Relying on natural ecosystem dynamics;
2. Active human intervention;
3. Initial limited human intervention that aims at accelerating natural processes (Khater, C., 2004).

In addition to the expected advantages that commonly result from rehabilitation of quarries and that include:

- promoting visual integration with the surrounding landscape,
- reduction of top soil erosion,
- acceleration of natural processes of vegetation dynamics and enhancing of vegetation establishment on site through intervention by re-vegetation.

The proposed scheme for the Sibline quarry was mainly developed to properly alleviate the impacts of the land filling activities on site.

The transferred inert material was contained within an impermeable geo-composite system. This was topped off by cultivable soil to host future plantation of olive and Carob trees as part of the rehabilitation scheme.

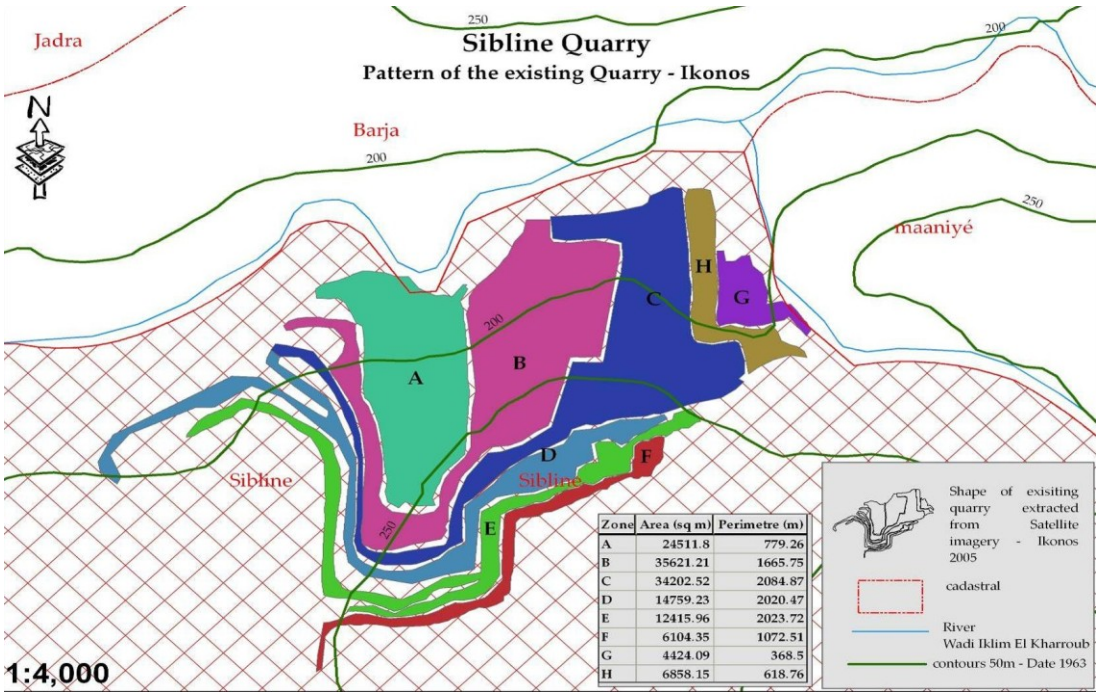


Figure 26 Pattern of existing quarry in Sibline with its different levels

The Renaturation of the Sibline quarry site involved the following stages:

1. Site preparation and landfill construction – Landscape creation;
2. Initial greening – revegetation phase;
3. Ecosystem development.

I) The site preparation and landfill construction i.e. Landscape creation consisted of the following (see Figures 27 – 42)
   1. Preparatory works including land grading;
   2. Laying of bottom liner (Liner 1, see Figure 32);
   3. Land filling the inert materials;
   4. Laying the upper liner (Liner 2, see Figure 36);
   5. Adding the top soil- agricultural soil (~1.5m);
   6. Installing the drainage systems for both the agricultural soil and the landfill lower base;
   7. Constructing a water storage pond for drainage and percolation water;
   8. Having earth ditches for routing the rainfall runoff water off the rehabilitated site.

II) Initial greening – Revegetation phase: this phase involves the actual on-site development of vegetation. 'Revegetation" is a technique that implies initiating vegetation development on a barren substratum. It can include not only planting of developed trees but as well sowing seeds of identified adapted species.

   For the Sibline quarry, the initial greening or re-vegetation phase mainly targeted the reclamation of the resulting quarry base platform after enriching it with top soil. Once the site preparation is achieved, and top soil is added, the rehabilitation scheme will involve transplantation of Olive and Carob trees along with all the requirements for proper growth and root development.

   Trees were transplanted on-site and with an average height of 1.3 to 1.5 m and an average trunk diameter of 7 cm. Each tree was transplanted in a 1x1x1 m hole previously filled with peat moss. Trees should be planted randomly with a minimum distance of 5 meters between trees and regularly watered during the whole summer season.

III) The re-vegetation phase was in turn followed by the phase of ecosystem development that relies on natural succession processes of the vegetation dynamics.

Figure 27 Inert materials at the Normandy Landfill

Figure 28 Dumping area within Sibline quarry

Figure 29 Leftover inert materials existing in the Normandy Landfill in Beirut

Figure 30 Leftover inert material transfer operation from Normandy Landfill to Sibline Quarry

Figure 31 Laying clay on the Geomenbrane

Figure 32 Laying of bottom liner (Liner 1)

Figure33 Inert material

Figure 34 Geotextile layer

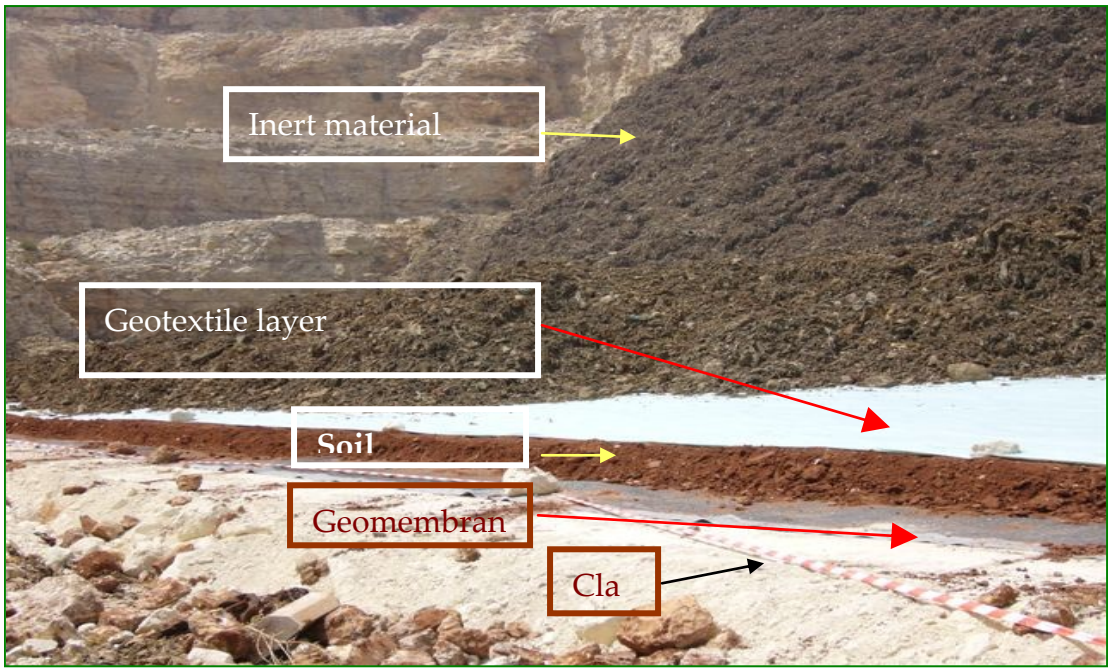


Figure 35 Different layers during the procedure of renaturation of the Sibline quarry

Figure 36 Laying the upper liner (Liner 2)

Figure 37 Drainage system and aeration hose

Figure 38 Adding top soil

Figure 39 Water storage pond

Figure 40 Preparation of the Sibline quarry for the revegetation with trees

Figure 41 Planting of Carob trees (*Ceratonia siliqua*), covering of mulch with net

Figure 42 Renaturated Subline quarry after three months, Carob trees can be irrigated with drip irrigation

6.7 Environmental and Socio -Economic Impact of the rehabilitation

- Impact Analysis

The potential environmental impacts associated with the proposed project during both the leftover inert material transfer/site rehabilitation and post closure phases were examined. The potential impact parameters for these two phases have a long and a short term effect (Table 35). The impact analysis was conducted on the basis of information provided by the contractor, field investigation and analysis of samples leftover inert material.

Table 35 Potential Environmental Impacts

Project phase	Duration	Potentially impacted parameters
Transfer of inert material/site rehabilitation	Short term	▪ Surface and groundwater quality; ▪ Soil quality; ▪ Odors; ▪ Air quality; ▪ Health and safety; ▪ Noise; ▪ Landscape and visual intrusion; ▪ Biological environment; ▪ Socio-economics; ▪ Traffic.
Post closure	Long term	▪ Surface and groundwater quality; ▪ Soil quality; ▪ Odors; ▪ Air quality; ▪ Health and safety; ▪ Noise; ▪ Landscape and visual intrusion; ▪ Biological environment; ▪ Socio-economics; ▪ Traffic.

The potential effect for the environment after renaturation of the Sibline quarry was investigated. The impacts on the environment were monitored at the Sibline quarry during the inert material transfer/site rehabilitation and post closure phases (Table 36).

Table 36 Assessment of different environmental impacts during rehab and post closure phases

Parameters	Potential Impacts according to phase	
	Inert material transfer/site rehab	Post Closure
Surface and groundwater quality(*)	0	-
Soil quality	0	0
Odors	0	0
Air quality	-	0
Health and safety	0	0
Noise	--	NA
Landscape and visual intrusion (*)	-	++
Biological environment(*)	0	++
Socio-economics(*)	0/-	+/-
Traffic	-	0
Cultural Heritage	NA	NA

+++	High potential positive impact	---	High potential negative impact
++	Moderate potential positive impact	--	Moderate potential negative impact
+	Low potential positive impact	-	Low potential negative impact
0	No significant potential Impact	NA	Not Applicable

For relevance purposes to the study objectives, only the most critical parameters among the aforementioned ones, marked in (*), were taken into consideration for further investigations.

The further investigation were concentrated on Landscape, Biological environment, Socio-economic situation and the Surface and ground water quality.

- Landscape and visual intrusion

During the leftover inert material transfer and site rehabilitation phase, minor visual intrusions were inevitable at the site due to the presence of equipment/machinery, material, soil heaps truck for transportation. Such impacts are common to any construction site and are limited to the short term construction period.

During the post closure phase, there will be significant positive impact on the landscape due to the increased vegetation cover on site. This will visually integrate part of the quarry site with the surrounding landscape; thereby decreasing the existing substantial negative visual impact of the non-operating quarry site.

- Biological environment

During the leftover inert material transfer and site rehabilitation phase, there were no impacts on the biological environment as all activities were strictly confined to the quarry site where no vegetation existed. During the post closure phase, there will be a considerable positive

impact on the biological environment due to the initiation of vegetation dynamics on site, which will result in ecological succession and subsequent changes in flora composition.

- Socio-economics

During both the leftover inert material transfer/site rehabilitation and post closure phases, local residents may have the perception of being exposed to health risks, which may lead to psychological stress. Positive socio-economic impacts consisted primarily of indirect benefits from an improved landscape of the rehabilitated quarry during the post closure phase.

- Surface and ground water quality

During the leftover inert material transfer and site rehabilitation phase, there was a minimal impact on the surface and groundwater quality due to the short time frame required (about one to two months) for the completion of this phase. These impacts were limited to accidental and unintentional spillage of oils and other petroleum products from vehicles and machinery used on site.

During the post closure phase, landfill percolation water might be accidentally generated within the rehabilitated quarry site, which falls on a highly permeable aquifer (C**4c** – Cretaceous Period, Sannine Limestone Formation) that is characterized by high secondary porosity causing groundwater to flow mainly through fractures, joints and channels. In general, high organic material, heavy metals and hazardous material may pose a significant threat to the surface and groundwater quality during the post closure phase. However, the leftover inert material used in the landfilling of Sibline quarry is not expected to pose a significant threat to the existing water resources falling in the vicinity of the site if proper mitigation measures are applied constantly and the landfill design components are properly implemented (including the double liner, the drainage systems and water collection and storage pond reservoir).

6.8 Evaluation of the methodology used for rehabilitation management

A rehabilitation and post closure scheme for a part of Sibline quarry was envisaged using DPSIR framework as a tool for assessing and managing the quarry rehabilitation problem.

It is worth mentioning that not all of the proposed mechanisms in the thesis recommendations were involved in the case study since some of them require time, commitment and long term planning from the government side to make it happens such is the case of promulgation of a new law that include the quarry post closure plan.

Table 37 illustrates the correlation between the findings of the thesis and the study case implementation.

Table 37 Comparative table between theory and practice

Recommendations in Chapter V	Study case Compliance
Proposed technical rehabilitation methodology	Yes (landfill and re-vegetation)
Proposed financial mechanisms for quarry rehabilitation	No contrary to table 44
Proposed institutional/administrative procedure for quarry rehabilitation	NA/ emerging problem
Proposed legal framework for quarry closure and rehabilitation in Lebanon	NA/ emerging problem

During and after the renaturation activities of the Sibline quarry we were able to validate the prioritization criteria previously mentioned in chapter 5.4.2 of the thesis study and to identify which criteria was the most prominent to the Sibline case study. Whether the criteria prioritised in case Sibline quarry are in compliance with the formulated criteria in chapter 5.4.2 were compared (Table 38).

Table 38 Evaluation of the criteria used for the renaturation and their compliance with the regulation

Prioritization criteria	Compliance with the regulation
Type of exploitation or quarry type;	Yes
Environmental and visual impact;	Yes
Impact on public safety;	No
Proximity to natural resources (water springs, protected areas, wetlands, rivers, etc.);	Watercourses
Proximity to residential areas;	Yes
Availability of an impact assessment study of the site;	Yes
Land ownership;	Private; Yes
Geographical location;	Yes
Willingness of the owner/operator to rehabilitate	Yes
Proximity to archaeological/touristic sites;	No
Site location and its effectiveness in acting as a successful rehabilitation model and raising public awareness;	Yes
Potential after uses (landfill, water reservoir, agricultural land, etc.);	Yes. Landfill
Availability of funds or bonds.	Government Initiative

For this case study, it was obvious that the availability of funds and the willingness of the landowner besides the geographical location were of high significance to the rehabilitation process.

Disadvantages of the methodology adopted

- Greeuw *et al.* (2001), stated that one problem of this framework is that the same item can appear in different components; depending upon which target we are focusing on. Also according to Kelly (1998) the framework fails to capture the complexity of the relationships in complex systems.
- The responses can become new pressures overtime and the effectiveness of responses can be directed back and examined to any of the four previous indicators. In general regulations are the most common form of responses existed. However, DPSIR framework is traditionally criticized for a mechanistic oversimplification of the scheme, scheme linearity and the difficulties in encompassing the multi-scale and multidimensional relationships of the environmental problems. Additionally, DPSIR framework also has the deficiency to handle the policies which can act both as a driving force and response (Klijn JA, 2004).
- Due to the absence of environmental indicators standards related to quarry rehabilitation at the national level (e.g. ratio of dust in the watercourses and air, etc…), it was not possible to make the proper measurements of the identified indicators and consequently to compare them to the national standards and norms. Therefore, the in-situ assessment would serve as the base line data to the activities undertaken in the rehabilitation process.

Advantages

- DPSIR is a model largely used and if these drawbacks are taken into account, it could work as a good tool to support the management of ecosystems. In addition, indicators are an excellent way of representing the environmental components avoiding the measurement of too many parameters. Indicators are often adopted to avoid and reduce the complexity of environmental data. In general, indicators are easily quantified and delineated from already described information in protective goods like environmental compartments and are adequate to assess what is called ecosystem health (Costanza, R. 1992)
- The idea of the framework was originally derived from social studies and only then widely applied internationally, in particular for organizing systems of indicators in the context of environment and, later, sustainable development.
- DPSIR is a model that offers a basis for analyzing the inter-related factors that impact on the environment.
- Its major application is on assessing and managing the environmental problems related to sustainable development therefore is useful for policy-makers. Besides, with DPSIR framework, all related parts within the system, e.g. driving forces, pressures, state,

impacts and responses together with their inter-collected causality can be discovered and identified. The ultimate goal of DPSIR framework is to evaluate the effectiveness and efficiency of the policy responses.

6.9 Conclusions of the pilot project - Sibline rock quarry

Sibline rock quarry in the Sibline cadastral area, Chouf Caza in the Mount Lebanon Governorate was selected to this research as a site to conduct the pilot case study on how to do rehabilitation due to several justifiable reasons.

Using the DPSIR Framework Model adopted by the European Environmental Agency in 1999 and different inclusive materials explained in the course of this part; it was possible to conceptualize the quarry rehabilitation process in the Lebanese context

The rehabilitation operation was initiated by the Government of Lebanon and extended over 7 months between year 2007 and early 2008. This operation included backfilling ≈15.000 m^2 of the quarry base level (A) showed in Fig 25 with ≈ 85.000 m^3 of the leftover inert material transferred from the Normandy Landfill. The rehabilitation ended-up by restoring the site thus allowing it, after adding a layer of top soil and the cultivation of carob trees (*Ceratonia siliqua*),, to be reintegrated into its surrounding environment.

The research sections and subsections represent an illustration of the integrated approach covering all related aspects to the rehabilitation process of an old rock quarry. Furthermore, it tackles the assessment of the site environmental base line data in order to appraise the impacts of the rehabilitation operation on the environmental and socio economical components of the rehabilitated site. An extensive evaluation of the methodology used was also handled as part of the work done to assess its compliance to the case study in the Lebanese context.

In brief, the case study succeeded in fulfilling its set aims and objectives to be the first rehabilitation scheme done at the national level based on a methodological approach.

7. GENERAL CONCLUSIONS, RECOMMENDATIONS AND PERSPECTIVES

The research selected Sibline rock quarry as a site to conduct the case study on how to do rehabilitation due to several justifiable reasons, which amongst the existing partial rehabilitation and the proximity to road network and infrastructure were of added value to the site selection criteria. The Sibline rock quarry is located in the Sibline cadastral area, Chouf Caza in Mount Lebanon Governorate at an altitude ranging between approximately 130m to 220m above sea level and falls in the Thermo Mediterranean vegetation level on limestone substratum.

Back to 1993-1994, the Sibline quarry served to extract approximately 16 million tons of rocks needed to achieve the extension of Beirut International Airport (BIA). In fact, the review of topographic maps, satellite imagery in addition to site survey reveals the existence six main uncultivated terraces and two sub terraces at the North East side of the quarry to ensure land stability and esthetic considerations (refer to table 46 and Fig. 25) covering an area of approximately about 138.898 (sq m).

Using the DPSIR Framework Model, adopted by the European Environmental Agency in 1999, it was possible to conceptualize the quarry rehabilitation process in the Lebanese context. This methodological approach served to study the problem of quarry rehabilitation and the inter-linkage existing in the Environmental chain between the different indicators involved in this Model. Consequently, responses were identified to the Driving forces, pressures, state, and impacts of the Sibline quarry which, as a result of the application of this analytical approach, consisted of rehabilitating a part of the quarry by backfilling it with leftover inert material transferred from the Normandy landfill which was causing an environmental hazard to Beirut central district sea façade.

Different Materials were also used to achieve the work progress and most importantly the site survey and on site investigation carried out before, during and after rehabilitation operation. The computer software was of great importance to compare the same location in different time scale and to overlap different layers needed to understand better the parameters affected by the investment of quarry and those to be taken into consideration in the rehabilitation process.

The rehabilitation operation was initiated by the Government of Lebanon and extended over 7 months during year 2007 and early 2008. This operation included backfilling ≈15.000 m^2 of the quarry base level (A) showed in Fig. 25 with ≈ 85.000 m^3 of the leftover inert material transferred from the Normandy Landfill. The rehabilitation ended-up by restoring the site thus

allowing it, after adding a layer of top soil and the cultivation of carob trees (*Ceratonia siliqua*), to be reintegrated into its surrounding environment.

By comparing the variance of the study case and the thesis recommendation along with the prioritization criteria, the following points/conclusions could be highlighted:

- Not all of the proposed mechanisms in thesis recommendations were involved in the case study since some of them require time, commitment and long term planning from the government side to make it happen such is the case of promulgation of a new law that include the quarry post closure plan;
- The technical rehabilitation scenario of the study case was compliant to thesis recommendation (rehabilitation through backfilling, use the site as landfill);
- The financial mechanism of the rehabilitation was not conforming to the thesis recommendation since it was based on Government Initiative;
- For this case study, it was obvious that the availability of funds and the willingness of the landowner besides the geographical location were of high significance to the rehabilitation process.

In conclusion, the thesis works succeeded in laying the way towards having an integrated approach to the natural resources management in Lebanon. However further steps are still needed to duplicate the demonstration in different areas with different type of exploitation. It is important to note that the financial section was not subject to discussion in this case study but it will certainly be a key issue in other case studies in this context. Other attempts should make use of the thesis findings and try to build further conclusions starting where the thesis ended.

8. EXECUTIVE SUMMARY

Due to complexity of the quarry sector in Lebanon, very few are the available data, records and studies in this field. However, the present research tackles one of Lebanon's most pressing issues and presents the most updated database on quarries in Lebanon.

In other words, the research not only represents an integrated overview of the quarries issue in Lebanon in general and the problem of rehabilitation in particular, but also extends to conclude the problematical topic of the integrated quarry planning within the sustainable development concept in Lebanon. The research also constitutes a milestone and landmark toward the adoption of a setup needed for the proper rehabilitation approach at different levels public sector, private sector and local communities.

The aim of the research was set to study the issue of integrated quarry planning for sustainable development in Lebanon and enhance the understanding of sustainable quarrying management practices in Lebanon.

The research's main objectives were to verify through in-depth study the status of rehabilitation practices in various types of existing quarries in Lebanon, identify the barriers that hinder the development and implementation of a sustainable rehabilitation program, address a sustainable procedure for natural resources management through conducting a case study and finally propose an algorithm for quarry rehabilitation to be adopted and conducted later on by another research studies in this domain.

A total of 471 site investigations according to an inclusive data sheet were conducted out of the total of 776 estimated numbers of quarries based on the results of the desk survey activity. Based on that, we were able to quantify different parameters among which was the rehabilitation status of quarries in Lebanon. The results showed among others that only 0.8% of the quarries were rehabilitated and 13% were partially rehabilitated and the rest 86.2% of the remaining quarries were not rehabilitated.

Given this fact, the research undertook a comprehensive inquiry including a national and international literature review in order to identify gaps and consequently recognize barriers that are hindering the rehabilitation from not being done until now in the proper way causing environmental damage and financial loss as seen in previous sections. At this stage, it was instrumental to study the cause of the non rehabilitation and try to overcome difficulties which were of different nature: legal, financial, technical, institutional and political.

The promulgation of two decrees (No 8803 in year 2002 and its amendment the decree No 16456 in 2006) by the Ministry of Environment was indeed an asset but nonetheless it was not

quite enough to ensure the proper rehabilitation of the quarries in Lebanon due to several reasons.

The research tried to answer the need of organizing the sector by proposing an algorithm that responded to the gaps already identified.

The recommendation made by the research is a proposal for a multidisciplinary law to be adopted by the government of Lebanon after getting the approval of all concerned stakeholders. In fact this algorithm in its fourth dimension legal, technical, institutional and financial needs two years to see the light but it will certainly help the country at the national level to witness quarries have began the rehabilitation practices and Lebanon will have the benefit of the principles of sustainability being practiced for the first time in its land. Moreover, the proposed algorithm will be pioneer for three major reasons: i) approving a mining region in Lebanon or the quarry master plan, ii) stop/forbid the issuance of the called administrative extensions and iii) propose a real setup for the abandoned non-operational quarries to be rehabilitated properly by law.

To validate theory (made by the research recommendations) and evaluate practice, an applied section on the how to do rehabilitation was carried out in year between 2007 and early 2008 to practically implement a rehabilitation scenario on part of an old quarry located in Sibline village situated in the northern side of Beirut the capital of Lebanon

Using the DPSIR Framework Model (Driving forces, pressures, state, impacts, responses) adopted by the European Environmental Agency in 1999, in addition to several relative materials it was possible to conceptualize the quarry rehabilitation process in the Lebanese context.

The rehabilitation operation was initiated by the Government of Lebanon and extended over 7 months during year 2007 and early year 2008. This operation included backfilling ≈15.000 m^2 of the quarry base level (A) with ≈ 85.000 m^3 of the leftover inert material transferred from the Normandy Landfill. The rehabilitation ended-up by restoring the site thus allowing it, after adding a layer of top soil and the cultivation of carob trees (*Ceratonia siliqua*), to be reintegrated into its surrounding environment.

The case study's aims was to address a sustainable procedure for natural resources management, examine and validate the different results and outcomes of the thesis and compares them to the different variable, variance, parameters, criteria that regulate most the quarry rehabilitation process in Lebanon. It also included a breakdown impact analysis of the rehabilitation undertaken on the environment as well as the methodology adopted to implement the rehabilitation section.

It is to be noted that the technical rehabilitation scenario of the study case was compliant to thesis recommendation (rehabilitation through backfilling, use the site as landfill). However not all of the proposed mechanisms in the thesis recommendations were involved in the case study since some of them require time, commitment and long term planning from the government side to make it happen such is the case of promulgation of a new law that include the quarry post closure plan. In the other hand, it was obvious that the availability of funds and the willingness of the landowner besides the geographical location were of high significance to the rehabilitation process.

Finally, the thesis works succeeded in laying the way towards having an integrated approach to the natural resources management in Lebanon. However further steps are still needed to duplicate the demonstration in different areas with different type of exploitation. It is important to note that the financial section was not subject to discussion in this case study but it will certainly be a key issue in other case studies in this context. Other attempts should make use of the thesis findings and try to build further conclusions starting where the thesis ended.

The proposed algorithm as well as the survey results and recommendations may be the core of other research studies to be implemented in Lebanon in order to validate and revalidate technically, financially, institutionally, legally the proposed algorithm before approving it by conducting a pilot case study to rehabilitate 5 abandoned quarries according to the several types of investment.

It worth mentioning that too many difficulties faced the progress of the study agenda since its starting date (e.g. availability of data, access to data, financial resources needed to make a pilot case, overlapping of authorities, tight timeframe to complete the study etc…).

The originality of the current research is that it is the first in its kind in Lebanon. No one before has tackled the issue due the enormous difficulties that might stop the workflow at any point of time. However, this research will certainly lay the way for other complementary studies and research from different scientific perspective (socio-economy, ecology, biology, agriculture, landscape engineering, geology, hydrogeology etc…) to be executed in this field.

Finally, this study resumed answers to the five most frequent asked questions i) why there is no to little rehabilitation in Lebanon, ii) when to rehabilitate, iii) which quarries to rehabilitate first, iv) how to rehabilitate and v) who is responsible for rehabilitation. Let me conclude by asking each Lebanese citizen this pertinent question:

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APPENDIX A

Direct related legislations to quarries			
Laws			
Ref. #	Number	Date	subject
1	216	02/04/1993	Mandate of MOE- initiation of MOE
2	667	29/12/1997	Amendment of MOE law
3	221	29/05/2000	Organization of water sector
4	444	08/08/2002	Protection of the environment
5	690	26/08/2005	Amendment of MOE law
Total		***5***	
Law decrees			
6	21	22/07/1932	Licensing authority
7	116	12/06/1959	Licensing authority, administrative organization
8	69	09/09/1983	Urban planning law decree
Total		***3***	
Decrees			
9	1119	04/11/1936	Licensing authority
10	1120	04/11/1936	Classification of crushers
11	5469	07/09/1966	Organization of the Ministry of Energy and Water
12	15649	21/09/1970	Organizational decree of sand dredging
13	4917	24/03/1994	Classification of crushers as dangerous industrial establishment
14	5591	30/08/1994	Organizational chart of MOE
15	5616	06/09/1994	organization of crusher and quarries
16	4082	14/10/2000	Licensing authority, Organization of the Ministry of interior and municipalities
17	8803	04/10/2002	Licensing authority, organization of crusher and quarries
18	9222	03/12/2002	Establishment of the national council for quarries
19	10608	05/09/2003	Amendment of decree No. 8803
20	10609	05/09/2003	Amendment of decree No. 8803
21	12849	03/07/2004	Amendment of decree No. 8803
22	16456	27/03/2006	Amendment of decree No. 8803
Total		***14***	

Council of Ministers decisions			
23	21	15/10/1991	Survey by the Lebanese army
24	12	07/06/1994	Study on quarries by a ministerial committee
25	3	09/06/1995	MOIM as licensing authority to issue administrative extension till the approval of the quarry master plan
26	11	09/07/1995	Ministerial committee to restudy the decree 5616/1994
27	3	20/09/1995	MOIM as licensing authority to issue administrative extension
28	54	07/02/1996	Closure of some rock quarries in a few prime area due to their negative impacts
29	35	19/06/1996	Closure of some sand quarries in few prime areas
30	16	09/10/1996	Confirmation on the council decision # 54/1996
31	67	27/12/1996	Closure of all quarries till the approval of quarry master plan and approve issuance of administrative extension by MOIM
32	1	05/03/1997	Extension of the issuance of the administrative extension by MOIM
33	4	12/03/1997	Adoption of the master plan by the 1996 Dar el Handasah study and the bonds principle
34	40	08/05/1997	Restudying the quarry master plan with the introduction of some changes
35	37	04/06/1997	Confirmation on the all council decision related to the closure of some quarries and forbid import of aggregates from occupied territories
36	31	28/08/1997	adopt the open dumps as a mean to rehabilitate the old quarries
37	25	14/01/1998	Ministerial committee to study the taxes and dues issue on quarrying activities
38	31	28/07/1999	Extension of the issuance of administrative extensions by the MOIM till the approval of the quarry master plan
39	6	12/04/2001	Restudying the quarry master plan
40	24	18/10/2001	Extension of the issuance of administrative extensions by the MOIM till the approval of the quarry master plan
41	17	20/06/2002	Extension of the issuance of administrative extensions by MOIM till the approval of the quarry master plan
42	2	11/07/2002	Approval on the draft decree organizing the quarries sector and on exempting the import of construction material from taxes
43	10	26/09/2002	Approval on the final draft version of the decree organizing the quarries sector

44	23	07/11/2002	Closure of all quarries not compliant with the decree No. 8803/2002
45	69	10/04/2003	Approve amendment of the decree No. 8803/2002
46	71	05/06/2003	Reconsidering the quarry master plan
47	14	05/09/2003	Approve amendment of the decree No. 8803/2002
48	25	18/09/2003	Follow-up on the decree No. 8803/2002
49	80	09/10/2003	Approve amendment of the decree No. 8803/2002
50	10	20/11/2003	Approve amendment of the decree No. 8803/2002
51	33	20/11/2003	Follow-up on the decree No. 8803/2002
52	49	03/12/2003	Follow-up on the decree No. 8803/2002
53	43	15/01/2004	Follow-up on the decree No. 8803/2002
54	37	30/01/2004	Approve reconsidering the quarry master plan mentioned in the decree No. 8803/2002
55	44	18/08/2005	Ministerial committee to restudy the issue of quarry master plan
56	22	06/09/2005	Approve issuance of administrative extensions by MOIM
57	45	06/10/2005	Postpone studying the report of the Ministerial committee on the quarry master plan
58	34	15/12/2005	Approve issuance of administrative extensions by MOIM
59	19	15/12/2005	Approve amendment of the decree No. 8803/2002
60	66	18/02/2005	Approve Issuance of administrative extensions by MOIM
61	42	08/06/2006	Approve Issuance of exceptional short permit by MOE till the entering in forth of the No. 16456/2006
62	39	19/10/2006	Approve extension of issuance of short permit by MOE till the entering in forth of the decree No. 16456/2006
63	6	04/01/2007	Approve Issuance of administrative extensions by MOIM
64	53	25/06/2007	Approve Issuance of administrative extensions by MOIM
65	28	03/01/2008	Approve Issuance of administrative extensions by MOIM
66	255	18/03/2008	Approve Issuance of administrative extensions by MOIM
67	87	10/10/2008	Renewal of administrative extensions by MOE till 31/12/2008
68	40	12/02/2009	Renewal of administrative extensions till 23/04/2009
Total		*46*	

Ministry of Environment Quarries ministerial decisions			
69	182/1	07/11/1997	Identifying documents required for each application in relation to different types of investment as well their subsequent conditions
70	183/1		
71	184/1		
72	185/1		
73	186/1		
Total		***5***	
Indirect related legislations to quarries			
74	188	1920	Clause 23 – decision on the protection of public health
75	392	1920	Clause 1 - decision forbidding excavation near Beirut bridge
76	253	1935	Clause 2, 21, 22, 26, 27, 50, 51, 52 – decision on the investment of quarries
77	2383	1943	Clause 1- decree forbidding excavation from Beirut river
78		07/01/1949	Clause 100 - forest law
79	116	1959	Clause 32 – law decree on Lebanese administrative organization
80	17702	1964	Clause 3 – decree organization of the coast shore in Jounieh region
Total		*7*	

APPENDIX B: DISTANCE CRITERIA FOR DIFFERENT TYPES OF QUARRIES

Distances criteria/m	Cement quarry (1)		Decorative stone quarry (2)	Mosaic quarry (3)		Sand, industrial sand and natural aggregates quarry (4)		Rock quarry with crusher (5)	Crusher without quarry. (6)
	Without blasting	With blasting		Without blasting	Little blasting	Sand quarry	Unconsolidated material quarry		
Sea Shore	1000	1000	500	1000	1000	1000	1000	1000	
Main rivers	500	500	50	500	500	500	500	500	
Secondary rivers	100	100	25	100	100	100	100	100	
Watercourses	25	25	25	25	25	25	25	25	25
Major springs	1000	1000	1000	1000	1000	1000	1000	1000	
Perennial springs	100	100	100	100	100	100	100	100	
Highways & international roads	300	500	200	300	500	300	300	500	200
Main roads	100	250	50	100	250	100	100	250	50
Local roads	25	25	15	10	10	25	25	25	
Industrial areas	250	1000		500	1000	250	250	1000	
Religious shrines	500	2000	250	500	1000	500	500	2000	500
Natural reserves	1000	2000	500	1000	1500	1000	1000	2000	500
Unclassified Archeological sites	500	2000	250	500	1500	1000	500	2000	500
Urban areas (more than 5 houses)	500	2500	200	500	1500	1000	500	2500	500
Urban areas (less than 5 houses)	200	1000	50	200	500	300	100	1000	200
Schools/Hospitals	1000	3500	250	1500	2500	1500	1000	3500	500
Other roads									15
Minimum surface area		20,000m^2	5,000m^2		5,000m^2		10,000m2	20,000m^2	5,000m^2

(1) Cement quarry without crusher for the cement production;

(2) Decorative stone quarry (without crusher);

(3) Mosaic quarry with small size crusher;

(4) Sand, industrial sand and natural aggregates quarry;

(5) Rock quarry with crusher;

(6) Crusher without quarry.

Environmental criteria:

All quarries should not induce direct damage on natural landscape, archeology, and the general environment. It is prohibited to invest quarries in the following area:

1. on the top of high hills that can be seen from the seashore and the international roads;
2. in areas of touristic and archeological importance;
3. in green lands;
4. in the areas of high biodiversity indicators.

APPENDIX C

Decisions made by the national council for quarries from Dec 2002 till end year 2008

Type of investment	Numbers
Decorative stone quarry (without crusher)	20
Mosaic quarry with small size crusher	12
Sand, industrial sand and natural aggregates quarry	8
Rock quarry with crusher	2
Crusher without quarry	17
Total	**59**

APPENDIX D

Distribution of the administrative extension issued by the MIOM in year 2006				
Type of investment	North district	South and Nabatieh districts	Mount Lebanon district	Bekaa district
Decorative stone quarry	18	16	10	24
Mosaic quarry with small size crusher	4	2	1	2
Sand, industrial sand and natural aggregates quarry	17	13	20	11
Rock quarry with crusher	13	36	12	47
Crusher without quarry	4	27	5	13
Stock transport	3	3	20	3
Related quarrying works	-	75	36	14
Total	59	172	104	114
Grand total				449

Distribution of the administrative extension issued by the MIOM in year 2007				
Districts	North	South and Nabatieh	Mount Lebanon	Bekaa
# of administrative extension	119	144	101	126
Grand total	490			

Distribution of the administrative extension issued by the MIOM till Midyear 2008				
Districts	North	South and Nabatieh	Mount Lebanon	Bekaa
# of administrative extension	1	133	72	4
Grand total	210			

APPENDIX E

International references as decrees and lows of relevance to the thesis

FRANCE	
Law No. 76-629 on Nature Protection	*10 July 1976*
Public Health Code, article L. 1321-2	
Code of Environment	
Law No. 76-663 on Classified Installations	*19 July 1976*
Decree No. 77-1133 implementing Law No. 76-663 of July 19, 1976 on Classified Installations for Environmental Protection	*21 September 1977*
Decree No. 77-1141 implementing Article 2 of the Law No. 76-629 of July 10, 1976 on Nature Protection	*12 October 1977*
Law No. 83-630 on the Democratization of Public Inquiries and Environmental Protection	*12 July 1983*
Law No. 92-3 on Water	*3 January 1992*
Law No. 93-24 on the Protection and Enhancement of Landscapes	*8 January 1993*
Decree No. 2001-1220 on water for human consumption	*20 December 2001*
Decree No. 2002-680 modifying the Classified Installations Nomenclature	*30 April 2002*
Ordinance on the General Prescriptions Applying to Quarries Submitted to Declaration in Accordance with the No. 2510 Rubric of the Classified Installations Nomenclature	*26 December 2002*
"Circulaire" for the implementation of the No. 2510 Rubric of the Classified Installations Nomenclature	*10 December 2003*
Public Health Code, article L. 1321-2	
Decree No. 2001-1220 on Water for Human Consumption	*20 December 2001*
GREAT BRITAIN (UK)	
The Noise at Work Regulations	*2 October 1989*
Town and Country Planning Act	*24 May 1990*
Environmental Protection Act	*1 November 1990*
Clean Air Act	*27 May1993*
Environment Act	*19 July 1995*
The Quarries Regulations	*12 July 1999*
The Pollution Prevention and Control (England and Wales) Regulations	*21 July 2000*

MALTA	
Environment Protection Act	*1991*
Development Planning Act	*1992*
Environmental Impact Assessment Regulations	*2001*
Environment Protection Act	*2001*
Minerals Subject Plan for the Maltese Islands	*2002*
TUNISIA	
Loi n° 89-20 Réglementant l'Exploitation des Carrières	*22 February 1989*
Décret n° 93-1631 Fixant la Composition, les Attributions et les Règles de Fonctionnement des Commissions Consultatives des Carrières	*2 August 1993*
Arrêté du Ministre de l'Economie et des Finances Réglementant l'Exploitation des Carrières	
QUEBEC	
Natural Heritage Conservation Act Environment Quality Act Regulation respecting pits and quarries Regulation respecting environmental impact assessment and review	*No date for the Quebec Laws and regulations as constantly consolidated.*

APPENDIX F

Quarry data sheet

Date of Visit* _____

Quarry operation

Operation Status*
- ○ Currently Operational / Active
- ○ Non-Operational/ Non active

Land ownership
- ○ Public
- ○ Private

Quarry Description

Location

Town / Village _____ **Coordinates** E _____

Cadastral Area (الخريطة العقارية) _____ N _____

Governate/Mohafaza _____ _____

_____ _____

Type of Quarry

Type of Quarry
- ○ Crushed Stone Quarry
- ○ Decorative Stone Quarry
- ○ Mosaic Quarry
- ○ Cement Quarry
- ○ Sand, Industrial Sand, Natural aggregate quarry

Soil pile
- ○ Yes

○ No

Face description * Estimation method

Face	**Height m**					

Site Description

Geological Setting

Geologic type

○ rock

○ Sand

Ecological Setting

Vegetative Cover & Natural Habitats

Type*	Cover**	Mix***	State****	Proximity*****

*Type: Endangered Species or Vegetation Type: Farmland, Forrest, Shrubland, Grassland

** According to conventional cover scale (i.e the 6-pt. Braun-Blanqet cover scale): absent **(0)**; few **(+)**; <10% **(1)**; 11-24% **(2)**; 25-49% **(3)**; 50-74% **(4)**; >75% **(5)**;

*** Indicate type: height <0.5m: **(h)**; 0.5-2m: **(a)**; 2-4m: **(A)**; >4m **(AA)** and scale according to Braun Blanqet above (1-6)

**** Not Degraded: **(ND)**; Degraded: **(D)**; Highly Degraded **(DD)**

***** Onsite: **(O)** Near <1 Km: **(N)** Intermediate (1-5 Km): **(I)** Distant (>5 Km): **(D)**

Environmental Impact of Quarry

Visual Impact

Quarry Visibility

Visual Receptors*	Degree of Quarry Visibility:				
	None	Slight	Moderate	Substantial	Major
* Visual Receptors: Residences, Archeological Site, Road, …					

Visual Impact of Quarry:

Visual Impact *(describe)*	Significance*
Introduction of visual intrustions (stockpiles, quarry faces …):	
Loss of landscape features (topography, vegetation, field patterns):	
Blocking views:	
* Significance: **(N):** Negligible; **(L):** Low; **(M):** Medium; **(H):** High; **(E):** Exteme	

Ecological Impact

Impact of Quarry on Ecology

Impact on Vegetation	Specify / Describe	Significance
* Significance: **(N)**: Negligible; **(L)**: Low; **(M)**: Medium; **(H)**: High; **(E)**: Exteme		

Existing Mitigation Measures:

Status of Quarry Rehabilitation

Rehabilitation Activities

Rehabilitation Activities*	Coverage	Status
	○ Insignificant ○ Partial ○ Entire	○ Completed ○ In progress ○ Planned

APPENDIX G

Land Settlement and Reclamation Procedure

Whereas the decree no. 16456 of 2/27/2006 (amendment decree no. 8803 of 10/04/2002 and its amendments related to the regulation of quarries and stone-carriers) stipulated in article 7 the land settlement and regulation provisions, the mechanism of permits issuance for land settlement and regulation is governed by the following:

1. Is considered land settlement and regulation, every exploitation activity undertaken by the petitioner to organize and settle a previous activity resulting from his exploitation of quarry, stone-carrier and sand pit – related activities of any kind that led to land disfiguration, damages or instability, provided that the site does not include quarry facades exceeding 8 meters height. This type of exploitation can also include mining.
2. Will remain outside the scope of this mechanism any activity, provided that these activities are legally licensed by the pertinent authorities, of the following type: •Agricultural, not resulting in a surplus of material such as stones and/or sands •Constructional (construction permits)
3. If the land settlement and regulation process requires the construction of a retaining wall, will be applied the construction law provisions and enacted decrees.
4. The application encompassing the documents required by the MoE for the land settlement and regulation shall be presented in a triplicate (an original and two copies) to the *Mohafez* who will forward it to the MoE – National Council for Quarries for the appropriate measures to be adopted.
5. The application will be forwarded back to the *Mohafez* with the approval or rejection of the MoE – National Council for Quarries and this decision will be abiding.
6. The operation timetable will be set according to the technical report information presented by the petitioner and the MoE – National Council for Quarries has the right to impose the suitable timetable pursuant to the technical inspection and the report information.
7. The *Mohafez* will issue a licensing decision if the MoE – National Council for Quarries has given its approval, it will include the timetable, technical and environmental terms that must be included within the land settlement and regulation activities issued by the MoE and are considered as an integral part of the licensing decision.
8. The petitioner will provide copies of the required periodic reports to the concerned municipalities for them to be able to assume their monitoring and follow-up responsibilities of the technical work in the field and then report back to the MoE –

National Council for Quarries any observation, if any, for the appropriate measures to be taken.

9. In case of incorrect information or documents provided by the petitioner, or in case of a violation of the technical and environmental terms specified in article 7 of this decision, all the operations will be stopped immediately and the license cancelled by a decision of the *Mohafez* in accordance with the National Council for Quarries decision without any acquired rights to the petitioner.
10. The operation fees stipulated in article 7 of the decree No. 16456 of 02/27/2006 will be defined by a decision of the finance minister pursuant to the provisions of the decree no. 8803/2002 and its amendments.
11. The amount of the bank guarantee stipulated in article 7 of the decree no. 16456 of 02/27/2006 will be defined by a decision of the minister of environment.

The documents required by the MoE for the Land Settlement/regulation applications		
	first: organizational documents	Observations
1-1	A full cadastral map + a statement of the property approximate areas.	
1-2	Delineation and servitude statement not exceeding one month from the application submission date	
1-3	Property attestation and realty attestation of fact of the un- surveyed areas non exceeding one month from the application submission date	
1-4	commitment to good operation practices	
1-5	Rental or exploitation contract or other	
1-6	Supervision agreement contract signed by an experienced geologist, civil engineer, architect, geo-mechanic, geo-hydrogeologist	
1-7	A map of the land location current status + longitudinal and latitudinal sections	
1-8	Topographic map at (1/20000) scale showing the property location	
	second: technical maps and documents	
2-1	Rehabilitation maps with longitudinal and latitudinal sections	
2-2	Timetable of the work progress	
2-3	Comprehensive photographic images of the location dated and signed by the concerned party.	
2-4	A tentative statement of the digging quantities and the expected surplus by a sworn and certified topographer registered at the topographers syndicate or a topographical engineer registered at one of the two engineers syndicate	
	Third: the municipality Council decision	
3-1	The municipality council decision/ or the district commissioner decision where there are no municipalities. (objections and complaints will be Appendixed to the municipality council decision in case of a disapproval)	Provided the municipality council decision encompasses the approval to transfer and use of surplus goods within the quantities estimated by the certified and sworn topographer or topographical engineer
	Fourth: reports	
4-1	Site rehabilitation reports	

General mandatory technical and environmental terms for the land settlement/regulation

1. It is absolutely forbidden to cut fruit, gum or pine trees.
2. No transfer of agricultural soil or rocks outside the real estate or use only for the land settlement/regulation prior to the approval of the MoE of the work execution, for the excess quantities only.
3. Preserving the rights of others, no trespassing on public properties and achieving the work as fast as possible.
4. Land use only for the stated purpose approved by the MoE under penalty of the immediate cessation of work.
5. Fencing the property with bushes or gum trees (or keeping the current tree fence), if the latter is not possible (solid rocky land) the fence will be replaced by a non-concrete material.
6. No use of explosives will be allowed at all with a written commitment in this regard.
7. No crusher of any kind or size will be installed for the production of gravel.
8. Submitting a performance bond which value will be defined by the MoE pursuant to the type and form of operation.
9. Operation fees and duties will be paid upon the promulgation of the licensing decision to the pertinent municipal fund or to the treasury outside the municipality.
10. The operator must build retaining walls pursuant to the land specifications with a maximum two-meter height from the natural ground level.
11. If the land is being leveled into platforms, the facades cannot be higher than 3.5 meters and the horizontal depth cannot be less than 3 meters.
12. The National Council for Quarries retains the right to impose new environmental terms when needed, to perform periodic monitoring; and the right to request the suspension of the license if the required environmental terms are not being implemented without any acquired rights to the concerned party.

APPENDIX H

A Comparative Table Showing the Amendments Made to Decree No. 8803/2002 through Decree No. 16456/2006

Decree No. 8803/2002	Decree No. 16456/2006
Article 1: Item 1.5: It is possible to install a crusher outside the quarry limit for designated period and for construction project provided that the crusher is removed when the Project is over.	**Article 1:** *Added:* 1.4 It is forbidden to invest in Natural reserves and natural sites and regional and national protected areas and water courses shown in the map attached to this decree. *Modified:* 1.5 It is possible to install a crasher outside the quarry limit for designated periods and for public or private construction project provided that the crusher falls within the project's borders and comply with the required technical and environmental conditions and that pursuant to decision of the Minister of the Environment based on the proposal of the National Council for Quarries. Type and scale of large construction Project is determined based on criteria determined by the National Council for Quarries and it can be categorized through Ministerial Decision of the Minister of Environment. These crushers should definitely be removed at the completion of the Project or pursuant to Ministerial decision based on suggestion from the National Council of Quarries 1.6 The Ministry of the Public Works and Transportation and the Ministry of Energy and Water are free to dispose the resultant of the works that they carry according to the observed laws measures. 1.7 For the installation of individual crusher without quarry, the authorization of the Ministry of Industry is obligatory.
Article 7: Item 12 An EIA study demonstrating the impact of the proposed quarry on the surrounding environment including:	**Article 7:** Item 12 An EIA study demonstrating the impact of the proposed quarry on the surrounding environment including:

Decree No. 8803/2002	Decree No. 16456/2006
▪ Methods of using, stocking and stowing explosives and the number of blasting experts hired for the job.	▪ Methods of using, stocking and stowing explosives and the number of blasting experts hired for the job. <u>*Added:*</u> *Blasting operations are authorized through a joint decision between the Ministry of Interior and the Ministry of Environment. Should any exploitation recur to the use of blasting method, periodical monitoring and inspection to measure underground vibrations will be conducted.* *Investors should record all blasting operations on a certified log book to be obtained from the Ministry of Environment which should include the following:* *7.1 Name of the Investor* *7.2 Authorization Number* *7.3 Plot Number – Cadastral area* *7.4 Type of exploitation* *7.5 Source of explosives* *7.6 Name of the responsible of blasting* *7.7 Quantity of explosives used* *7.8 Time of blasting* *7.9 Method of Blasting* <u>*Added Item 14:*</u> *An agreement should be made a priori between a geologist or civil engineer or architect or geo-mechanical engineer or hydro-geologist and the investor for subcontracting all monitoring works. In addition to a pledge explicitly stating that the subcontractor will assume full responsibility in supervising all works in the quarry and associated crusher…* *It is the duty of the investor to inform and get the MoE approval of the changes occurring in the investment including the person in charge of the supervision and the reasons.* *Every trimester, the subcontractor should submit to the Ministry of Environment comprehensive report on the progress of the work and its compliance with the original plans/proposal including photos. These reports should be dated*

Decree No. 8803/2002	Decree No. 16456/2006
	and signed by the supervisor and the owner of the investment. *Topographic maps should be attached to the progress reports showing the changes that occurred with estimations of the extracted volumes and their compliance to the originally declared quantities. These maps should be prepared by consulting offices accredited by the National Council for Quarries.* *Providing false information will result in an immediate cessation of all works…* *The investor should forward the above mentioned progress reports to the concerned municipality or otherwise to the governor (Kaem-makam) so they can be informed to follow up on the various implementation phases…* *Added Item 15:* *Prior approval of the Ministry of Energy and Water – Directorate General for Investments*
Article 8: Three copies of the application must be submitted and then forwarded to the National Council of Quarries, the Ministry of Interior and Municipalities and the concerned Municipalities. The Municipality would consult with the local community regarding the application for any new quarry particularly those residents who would happen to live within 3000m from the proposed quarry. Should there be any contention; item 51 of Municipalities Law shall be applied…	**Article 8:** *Three copies of the application must be submitted and then forwarded to the National Council of Quarries, the Ministry of Interior and Municipalities and the concerned Municipalities.* *The Municipality would consult with the local community regarding the application for any new quarry particularly those residents who would happen to live within 3000m from the proposed quarry.* *Should there be any contention; item 51 of Municipalities Law shall be applied… The prior approval of the local council is mandatory.*
Article 11 In addition to the required logbooks, all accounts of the various exploitation activities and production must be recorded and submitted for review by MoE…	**Article 11** *In addition to the required logbooks, all accounts of the various exploitation activities and production must be recorded and submitted for review by MoE…*

Decree No. 8803/2002	Decree No. 16456/2006
	Added *…These accounts are to be verified and stamped by the Directorate General for Environment bearing each a serial number so that local authorities can verify the trueness of the information provided….* *These log books will have serial numbers and shall include the following information:* *11.1 Name of the Investor* *11.2 Origin of the goods / loads* *11.3 Type of goods / loads* *11.4 Name of the driver – name of the truck owner- truck number* *11.5 Load of the truck – weight unloaded and weight loaded* *11.6 Direction of transport* *11.7 Name and signature of the investor and date* *11.8 Signature of the recipient and date*
Article 23 Exploitation taxes...	**Article 23** *Exploitation taxes...* *Added* *Any land arrangement that may generate excess of rocks or/and sand material will be subjected to current fiscal regulations… In addition a bond will be required to ensure that all environmental conditions are respected.*